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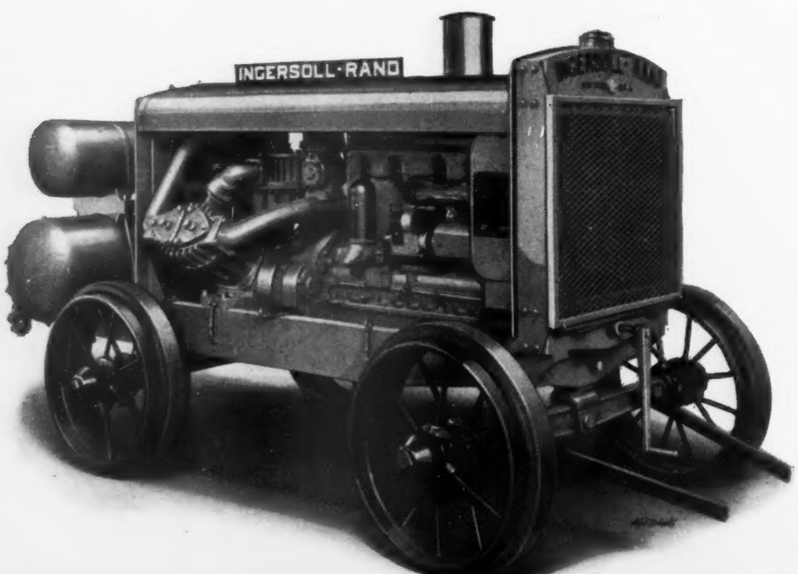

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A Monthly Publication Devoted to the Many Fields of Endeavor in which Compressed Air Serves Useful Purposes

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Compressed Air Magazine

MAY, 1935

Volume 40 | Number 5

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Annual subscription rate: Domestic, $3.00, Foreign, $3.50. Single copies, 35 cents.

Manuscripts intended for editorial consideration should be accompanied by return postage.

Hydrogenation—A Feat of Modern Alchemy

C. H. VIVIAN

THE petroleum industry offers a curious anomaly, a strange contrast of prodigality and thrift. On the production side there is admittedly considerable waste. The refining end of the business, on the other hand, is the acme of frugality.

The reason for this striking difference is a simple one. Refining processes can be controlled, production methods cannot. In a recent magazine article, Sec. Harold L. Ickes of the U. S. Department of the Interior deplored the extravagances which attend the existing system of producing crude oil. He pointed to the astounding dissipation of natural gas, a substance which is valuable in itself, but which is far more valuable, if left in the ground, as a propulsive medium for lifting petroleum to the surface. He likened our loose arrangement of drawing oil from its natural storehouse to a debauch which was certain to hold in its wake a headache of higher gasoline and fuel-oil prices and which, perhaps, might even make us dependent upon foreign sources for these vital necessities.

This article is concerned only with the refining side of the oil industry, and with but a single new development in that field. It does, however, have some bearing upon the matters just mentioned in that it illustrates how scientific advancement, by showing how to make a barrel of crude oil go several times as far as it once did, has offset to a great extent the wastefulness which still permeates the production branch. It also serves to emphasize the fact that so far as the major oil companies are concerned, the purpose and aim is to conserve rather than to destroy. This should be readily understandable from the dollars and cents standpoint alone, for, in the final analysis, the oil companies are in business for profit, and by squandering their raw material—petroleum—would be but hastening their own doom.

The evils of production are largely beyond the regulatory powers of the major oil companies. The very nature of petroleum is to a great degree responsible for its lamentable waste. Gold, coal, or any other solid mineral will remain in the ground where it was formed until it is dug from its position; and the owner of such a deposit need have no fear that it will suddenly disappear. Petroleum, on the other hand, because it is a fluid, flows more or less readily through its inclosing rock structure if an outlet is available within a reasonable distance. With a high gas pressure tending to propel it, and the weight of overlying rock strata exerting a squeezing action upon it, a large portion of the oil beneath a given tract of land may, and often does, move to or toward the bottom of a well put down on a neighboring plot.

Accordingly, it behooves every landowner to act for his own protection. This is, in its simplest form, the reason for feverish drilling programs, with attendant overproduction, wastage of gas, and stealthful disregard of quotas and other edicts. In practice, of course, it is much more complicated, for usually it is not the owner at all that does the drilling, but the oil company to which he has leased his land. However, the same principles apply, and with

REACTION CHAMBERS

This picture was taken inside one of the two concrete hydrogenation stalls at the Bayway, N. J., plant of the Standard Oil Company. Each reaction tower is 40 feet high and has laminated alloy-steel walls 7 inches thick. Within them, oil and hydrogen at 3,600 pounds pressure per square inch and temperatures up to 1,000°F. react in the presence of a catalyst. The molecules of oil are broken up to be re-formed with the addition of hydrogen. By varying the pressure and the temperature, a number of different products may be made.

How Molecules of Petroleum are Torn Apart by Pressure and Heat and Reconstructed with the Addition of Hydrogen to Form New and Varied Products Almost at Will

scores of producers in a field, some large and some small, some long-established and some of the fly-by-night character, it is sometimes hopeless to attempt to proceed in an orderly manner with field development that will produce the greatest amount of oil eventually but will yield little or nothing to numerous landowners and companies for the present. In a few fields where the interests have been held by a few owners, it has been possible to reach production agreements, and in such cases it has been effectually demonstrated that conservation and production are compatible.

Turning to the refining branch we find, as already mentioned, that there has been constant alertness and consistent research, resulting in continual improvements in processes with a consequent progressively greater conservation of the raw material on the one hand and a betterment in the quality of the various products on the other hand. We have it on the authority of Axtell J. Byles, president of the American Petroleum Institute, that the public's demand for gasoline is now being met with half the quantity of crude oil that would have been required only seventeen years ago. Mr. Byles further declares that the 1934 average price of gasoline was just half that which prevailed fifteen years ago. These two facts epitomize the advance in the refining industry in terms of effect upon the motorist's pocketbook. To complete the financial picture, however, we must record that taxes totaling $754,000,000 were tacked on to the retail price of gasoline and lubricating oil last year by the various Federal, state, county, and municipal governments.

The refining of petroleum can rightfully be classed as a branch of the chemical industry. In the beginning, it consisted merely of boiling the crude oil in an iron vessel and of collecting and condensing the vapors that were driven off. Closeness of control was impossible, the products of one run varied greatly from those of another, and a lot of the original stock never reached a marketable stage. For that matter, kerosene was the bread and butter of the industry, and almost the cake as well. The invention of the automobile put an emphasis on gasoline. Subsequently, the discovery of new uses for other products and the increase in the demand for uses already known proceeded until now there is no such thing as wasted proportions or untreatable residues.

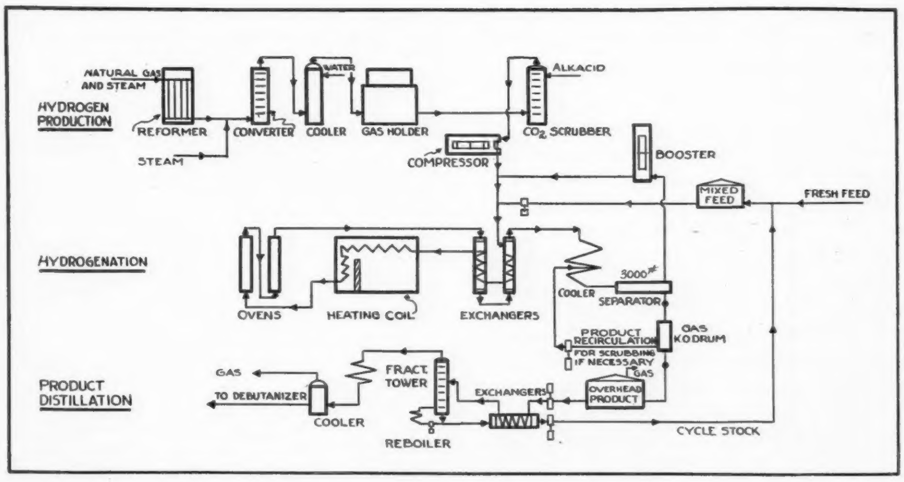
The history of refining technique discloses a steady march forward. Processes which were hailed as revolutionary when they first came along were relegated to the scrapheap in surprisingly short periods. Costly plants were torn down to make way for better ones almost before they had become nicely adjusted. Millions of dollars were spent, only to have what they represented cast aside for improved apparatus. In no other industry was obsolescence a greater factor.

Despite the often hurled charge of "oil trust," the fact remains that keen rivalry has existed among companies and even among different units of a company. Each has been zealously striving to outdo the others. All this is still going on: it is evident in periodical advertising campaigns and in radio announcements of modernized equipment and processes which enable this or that concern to offer an improved product. Not always, of course, is the advance so great as it is represented to be, for the merchandising instinct is sometimes allowed to gain the upper hand. Nevertheless, steady progress towards more efficient methods is undeniably being made. Naturally, there is an optimum condition to be arrived at—a degree of effectiveness beyond which it will be impossible to go. The indications are that it is already being approached, for by the new process of hydrogenation a barrel of crude oil can be converted into almost any of its derivatives—in other words, a full barrel of gasoline, for example, can be produced from a barrel of petroleum. In fact, strange as it may seem, it is possible in some instances to get more than a 100 per cent yield.

Hydrogenation, in essence, simply means adding hydrogen to a substance under conditions that will cause the hydrogen to enter into a more or less stable combination. As will be seen, the conditions under which such a union is feasible are usually created by setting up high temperatures and high pressures. The process originated in Germany. Haber and then Bosch, demonstrated that nitrogen and hydrogen could be combined to form ammonia, which could then be converted into nitrates.

Development of the process to a state of high efficiency enabled Germany to go on making explosives during the World War even though her supply of natural nitrates from Chile was cut off. Synthetic ammonia is produced by hydrogenation, as has been described previously in these columns. Haber and Bosch first applied the method in 1912. Three years later Bergius showed that powdered coal and hydrogen could be combined to produce liquid hydrocarbons similar to those derived from petroleum by distillation.

The commercial exploitation of the process was undertaken at the termination of the war by the great German dye trust, the I. G. Farbenindustrie Aktiengesellschaft. Continuation of the experiments made it possible for Bosch to announce, in 1926, that the process was suitable for treating the poorer grades of brown or lignite coal in Germany. For their contributions to the knowledge of hydrogenation, Doctors Bosch and Bergius were awarded the Nobel prize in 1931. Interest in the method in Germany ran primarily to the production of oil from coal, by reason of the fact that that country has large deposits of low-grade coal but virtually no petroleum. Investigations clearly indicated, however, that hydrogenation could be advantageously applied to the treatment of petroleum. Its possibilities attracted the attention of the Standard Oil Company (New Jersey) and,



SIMPLIFIED FLOW SHEET

The sequence of the essential operations involved in the hydrogenation of petroleum is shown here in simple, graphic form. The example given is for the manufacture of gasoline, but only slight modifications are required for making lubricating oil.

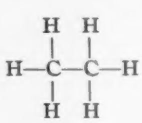
COMPRESSOR HOUSE

The large building in the center contains the compressing equipment for raising the pressure of the hydrogen gas to 3,600 pounds per square inch preparatory to its reaction with the oil. This is one of the largest installations of high-pressure compressors in the country.

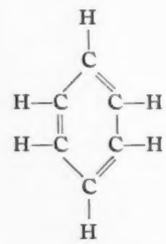
in 1926, that concern and the I. G. Farbenindustrie signed an agreement providing for the mutual development of the process.

The Standard Oil Company erected, at Baton Rouge, La., an experimental or pilot plant having a capacity of 100 barrels daily. It was operated long enough to enable the company's scientists to determine just what could be done with petroleum by hydrogenation, how best to do it, and what equipment would give the most satisfactory results—in short, to gather the knowledge necessary for putting the process to work successfully and profitably on a large scale. In 1929, construction was started at Bayway, N. J., on a commercial plant, and a little later a second one was begun at Baton Rouge. After a suitable test period, to assure smooth and efficient functioning, they were put on a production basis, and since then they have steadily made hydrogenated products for the market.

In order that we may understand how hydrogenation acts, it is desirable to consider the chemistry of petroleum briefly. Petroleum is a mixture of chemical compounds of carbon and hydrogen, with smaller amounts of sulphur, nitrogen, and oxygen. The hydrocarbons are of two principal classes: the aliphatic group, and the carbocyclic or aromatic group, and these are distinguished by differences in their molecular construction. The aliphatics are of the so-called open-chain type. We can illustrate this with a graphic representation of ethane, C_2H_6

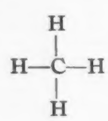


In contrast to its open structure, note the ring of carbon atoms in the following picturization of benzene. C_6H_6



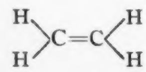
All aromatic compounds contain such a ring in some form of combination.

Reverting to our high-school chemistry for a moment, we recollect that the valence of an element is the combining or saturating capacity of one of its atoms as compared with that of an atom of hydrogen. The valence of hydrogen is one, and that of carbon is four. In other words, in any chemical union between these two elements it takes four atoms of hydrogen to satisfy the demands of each carbon atom. The simplest compound which meets these requirements is the gas methane, whose chemical symbol is CH_4. Represented graphically, methane appears as

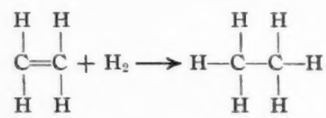


It will be noted that each hydrogen atom is held by a single bond while the carbon atom has four connecting bonds. Such a compound is said to be saturated, because there are sufficient hydrogen atoms to satisfy the carbon atom completely.

Consider, by way of contrast, the hydrocardon ethylene, C_2H_4. In picture form it is represented by



Because there are not enough hydrogen atoms to satisfy the valence of the two carbon atoms the latter are assumed to be joined to one another by two bonds. Such a compound is called unsaturated. It is characteristic of unsaturated hydrocarbons that the molecules are more unstable than those of saturated hydrocarbons. That is to say, it is comparatively easy to break down a molecule of ethylene, for example, and to bring about its reconstruction into a new compound wherein all the unsaturated carbon bonds will be satisfied by additional hydrogen atoms. The process of transforming double or triple bonds into single bonds through the addition of hydrogen constitutes hydrogenation in its simplest form. In the example under discussion, the ethylene is converted into ethane. Symbolized, the reactions appear as follows



In addition to this type of reaction, numerous other complex changes can take place wherein molecules are partly broken down through the introduction of hydrogen, or wherein new combinations are formed.

In the widely practiced refining process known as "cracking," hydrocarbon molecules are broken up by heat, with or without pressure, and recombined to give a higher proportionate yield of motor fuels than is obtainable by simple distillation. By this method it is possible to convert a considerable portion of the heavier fractions of petroleum into the more valuable gasolines and naphthas. A typical cracking reaction is represented by

$$\underset{\text{Pentadecane}}{2C_{15}H_{32}} = \underset{\text{Octane}}{2C_8H_{18}} + \underset{\text{Methane}}{7CH_4} + \underset{\text{Carbon}}{7C}$$

In the simple distillation of petroleum, the lighter compounds or fractions volatilize and pass off first, then the next lighter and so on, progressively. In refinery language, these are "cuts." In the case of Pennsylvania crude oil, for example, the cuts are differentiated according to gravity, as follows: crude naphtha, crude kerosene, gas oil, wax distillate, and cylinder stock. It so happens that the simpler and lighter hydrocarbons are harder to crack than the more complex and heavier ones. Thus, kerosene distillate, for instance, is more difficult to break down than gas oil. It requires higher temperatures and pressures and more time. Accordingly, in order to obtain additional yields of gasoline, it is but natural that the heavier cuts should be

the ones most frequently used in cracking.

The hydrogenation process which has been put to use by the Standard Oil Company goes further than cracking. By means of heat and pressure it rends the hydrocarbons asunder, then introduces additional hydrogen in sufficient amounts and under suitable conditions to bring about their reconstruction, as desired. By varying the operating conditions the product can be varied. In other words, the process is flexible: it can turn out gasoline, kerosene, lubricating oil, solvents for paints, lacquers, and other materials. At present it is serving to make a lubricating oil that is marketed under the name "Essolube."

From the standpoint of demonstrating the facility with which the process can be adapted to meet requirements, it is interesting to record that for a period of five months during 1931 the entire capacity was devoted to the making of kerosene exclusively. Not the least surprising point about this is the realization that there still remains, in this age of gasoline, a large-scale demand for kerosene. In the instance under discussion, an increase in the use of kerosene stoves appears to have been responsible for the heavy demand.

The process, as compared with older methods of treating crude oil, apparently has few disadvantages and many advantages. It can be applied to raw petroleum, or to distillates or residues resulting from other refining processes. The products, whatever they may be, seemingly can be made of equal quality regardless of the source of the crude oil from which they are derived. Moreover, their quality is as high as and in some cases higher than similar products obtained by other refining methods.

In conventional refining processes, impurities such as sulphur, oxygen, and nitrogen are removed from the petroleum not by themselves but in combination with hydrocarbons in which they exist as molecular compounds. Hydrogenation, on the other hand, eliminates them without taking out the entire molecule of which they are a part. The remaining molecular structure absorbs hydrogen and eventually becomes a part of the refined product, instead of being discarded as waste. This is one of the chief reasons why refining losses are cut to a very low point, or are virtually done away with.

It will be seen that hydrogenation, by its very nature, is especially well adapted for the production of high-grade automobile lubricating oils. Within recent years, the automobile engine has been increased in power by one-half and in speed by one-quarter with no increase in size. These changes have brought about troublesome problems in lubrication. A satisfactory oil for modern high-compression engines must possess certain essential characteristics. It must remain fluid and permit of easy pumping and ready distribution to bearings at low temperatures, and it must retain its body at high temperatures. It must resist

THE BAYWAY PLANT

Thus far, only two plants for the hydrogenation of petroleum have been built in this country, one at Bayway, N. J., and the other at Baton Rouge, La. This is an aerial view of the New Jersey plant. The concrete stalls which house the reaction towers are at the right-hand end.

breakdown from oxidation at high temperatures with the consequent formation of sludge. It must not form hard, resistant carbon deposits. It must be consumed slowly and require infrequent changing. Hydrogenation, by breaking down the molecules and rebuilding them, makes it possible, so it is claimed, to control the properties of the final product at will—in short, to produce an oil that satisfies all these major requirements.

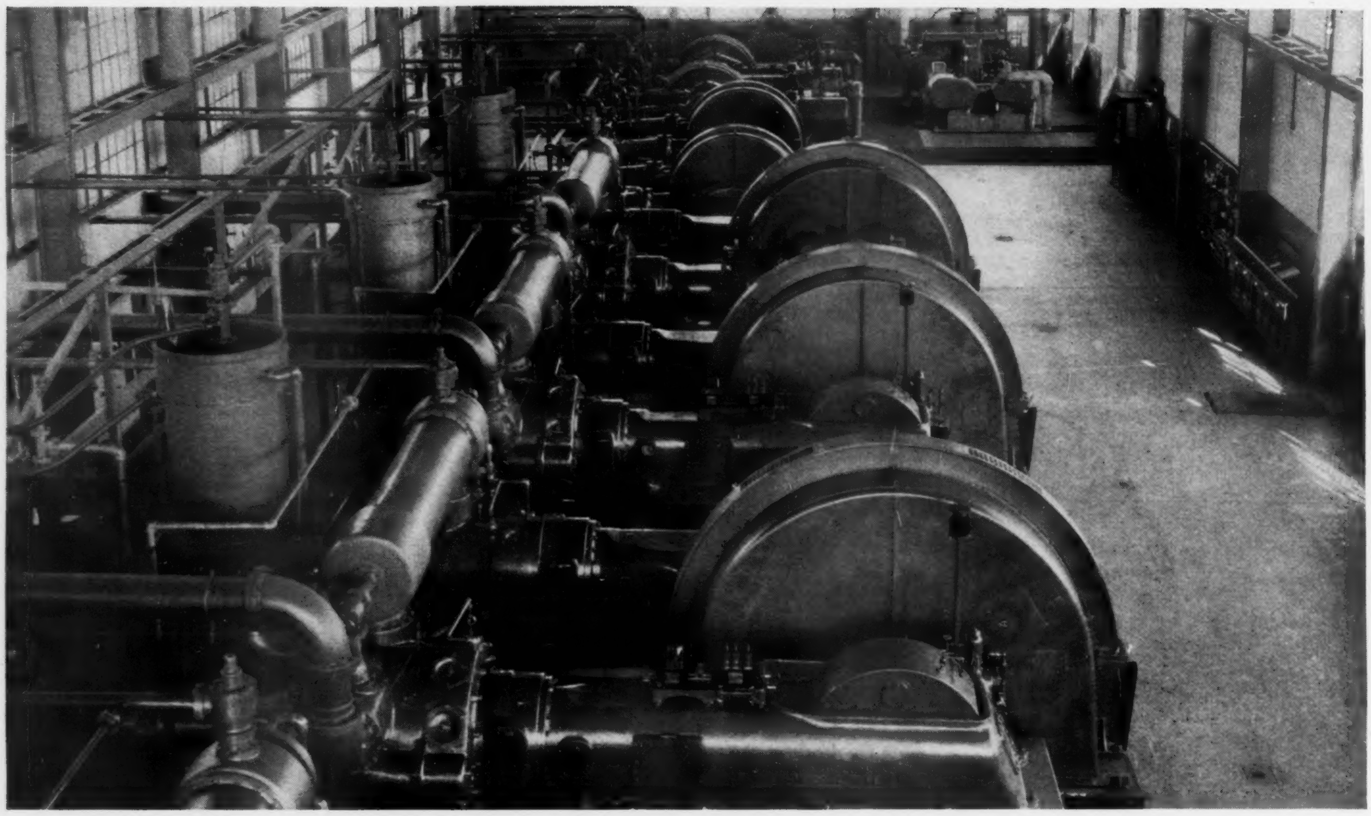
As the plants at Bayway, N. J., and Baton Rouge, La., are essentially the same, the description of the operating procedure will be limited to the former. That plant has two hydrogenation units, each housed in a concrete stall. Each unit will treat from 2,500 to 5,000 barrels daily, depending upon the character of the charging stock and upon the ultimate product. The higher capacity can be reached when gasoline is being produced. When making lubricating oil, as is now being done, the charging rate ranges from 1,500 to 3,500 barrels daily. The reactions which result in lubricating oil take place with the charging stock in the liquid phase. In the manufacture of gasoline, however, the stock is in the vapor phase, owing to the higher temperature used.

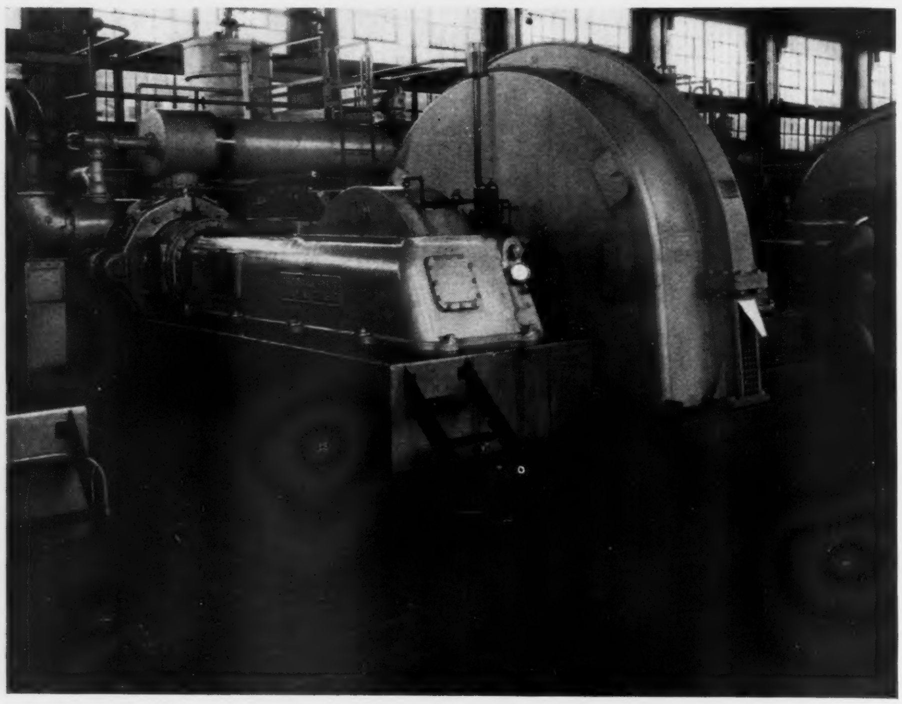
Hydrogen, which may be produced in several ways, is made of cracking-coil gas, which is obtained by the company in some of its refinery operations at Bayway. After being treated for the removal of sulphur and other impurities, the gas is mixed with steam and passed at a high temperature through tubes which contain a suitable catalyst. A catalyst, it will be remembered from school days, is a material which undergoes no change itself but whose presence assists and accelerates a desired chemical reaction. The reaction, in this instance, takes place between the hydrocarbons in the gas and the steam, and is as follows:

$$CH_4 + H_2O = 3H_2 + CO$$

More steam is then introduced, and a second reaction effected with the hydrogen-carbon monoxide mixture at a lower temperature. This produces carbon dioxide and hydrogen, together with about 1 per cent of unconverted gases. After being cooled, the mixed gases are led to a holder to await their use.

The hydrogenation process requires that both the charging stock and the hydrogen gas be put under a pressure of approximately 3,600 pounds per square inch. So far as the gas is concerned, this is done by means of specially built compressors supplied by Ingersoll-Rand Company. In the Bayway plant alone there are ten such machines, most of them of huge size as compared with conventional compressors for construction work and similar purposes where discharge pressures are ordinarily not more than 100 pounds per square inch. Six of these compressors are of the 4-stage type and serve to compress the gas from atmospheric pressure, or a slight positive pressure, to the final discharge pressure of 3,600 pounds. The four others are single-stage machines whose function it is to recompress gas which is recycled after having passed through the hydrogenation reaction without combining with the charging stock. During the reaction, the pressure drops from 3,600 pounds to approximately 2,800 pounds, and the latter units restore it to the operating pressure. Five of the compressors are electric driven and five are steam driven. Their combined horsepower is around 5,000.





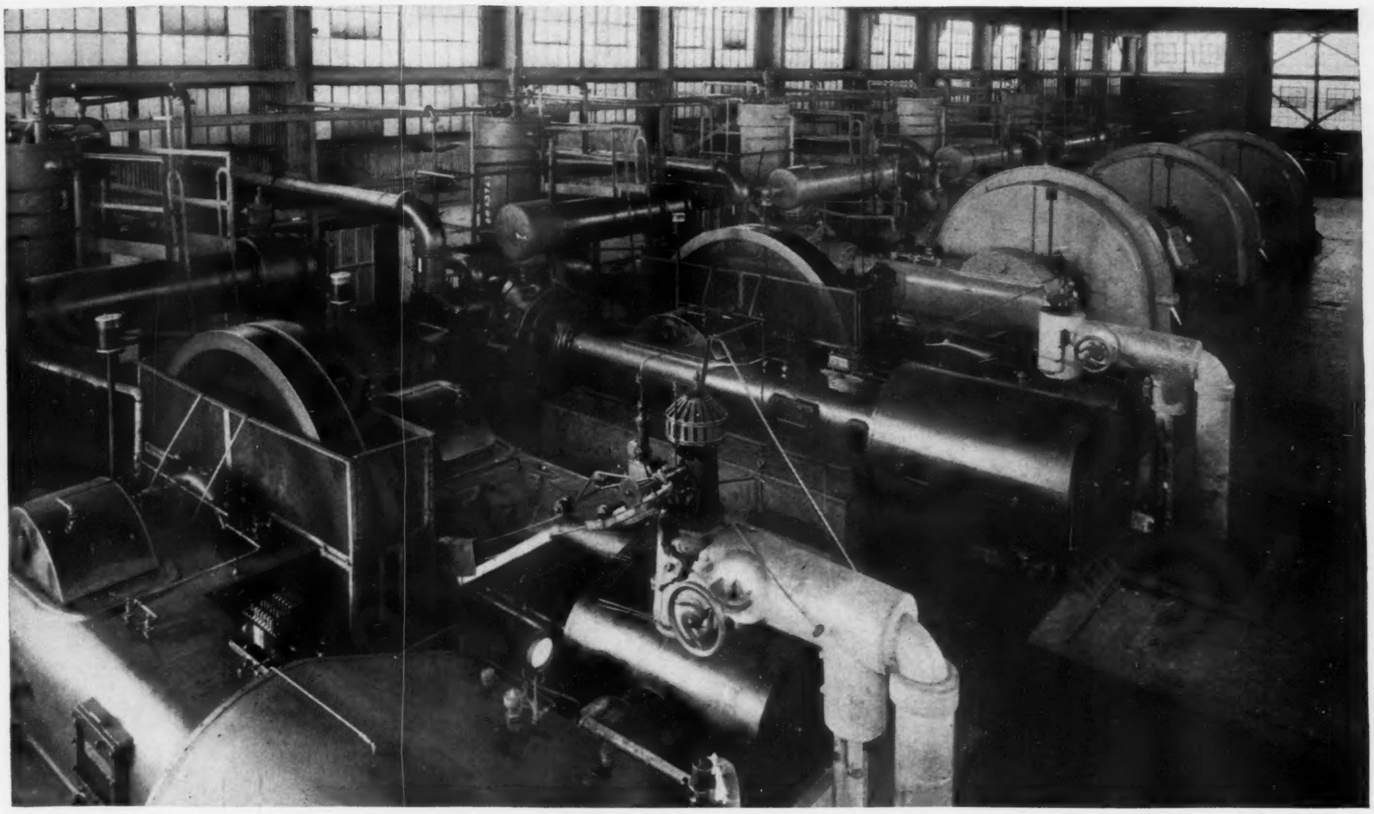
HIGH-PRESSURE COMPRESSORS

A vital requirement of the hydrogenation process is that large volumes of hydrogen gas be brought to the reaction pressure of 3,600 pounds per square inch. This is done at Bayway by means of ten compressors, all housed in one room. Their combined horsepower is approximately 5,000. The general view shows eight of these machines. The second picture affords a close glimpse of one of the units.

As generated, the gas consists of approximately 79 per cent hydrogen, 20 per cent carbon dioxide, and 1 per cent unconverted hydrocarbons. Between the second and third stages of compression, when its pressure is about 240 pounds per square inch, most of the carbon dioxide is removed from it by passing it countercurrentwise to sea water through a packed scrubbing tower. The pressure causes the carbon dioxide to dissolve in the water, and its percentage is thereby reduced from 20 to around 0.6.

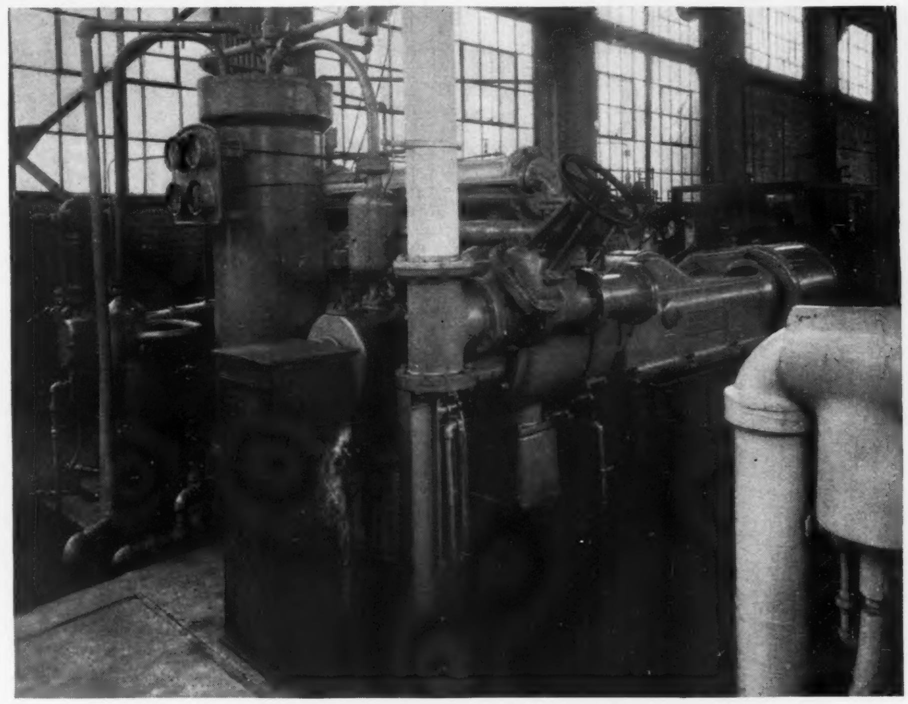
The feed stock is raised to the required pressure of 3,600 pounds per square inch by means of high-pressure pumps, and is brought together with the hydrogen through a T connection. The first step in the hydrogenation process is to preheat this mixture in heat exchangers located within the concrete stalls, the heat being supplied by the hydrogenated products coming from the reaction chambers. The mixture is then raised to the reaction temperature in a gas-fired coil; but as the subsequent hydrogenation reaction itself is exothermic, or heat-producing, the coil needs to be furnished with only a comparatively small amount of heat.

Having been brought to the required pressure and temperature, the oil-gas mixture is led through one of the cylindrical reaction towers, of which there are four in each unit. These towers are 40 feet high, 3 feet in inside diameter, and have 7-inch-thick walls made up of several laminations. The towers are packed with a catalyst, which assists the reaction through which the oil and some of the hydrogen are caused to unite. The reaction products pass out of the tops of the chambers and then through the heat exchangers and a cooler to a release drum. There the uncombined hydrogen gas and liquid are separated. The liquid goes to a low-pressure separator where the pressure is maintained at about 75 pounds per square inch. Any gas that is still present is drawn off and sent to the burning line, while the liquid products are scrubbed to remove hydrogen sulphide and are pumped to storage. The gases which are separated in the high-pressure release drum are led to an oil scrubber for the removal of inert gases, after which the remaining hydrogen is fed to a booster compressor which raises its pressure to the re-



ADDITIONAL COMPRESSOR VIEWS

Six of the ten compressors are of the 4-stage type. The four others, which are for booster service, are single-stage units. Five of the machines are steam driven and five are electrically driven. The general picture shows two large steam-driven units in the foreground, with three motor-driven machines just beyond them. The other view is a close-up of one of the 4-stage steam-driven compressors.

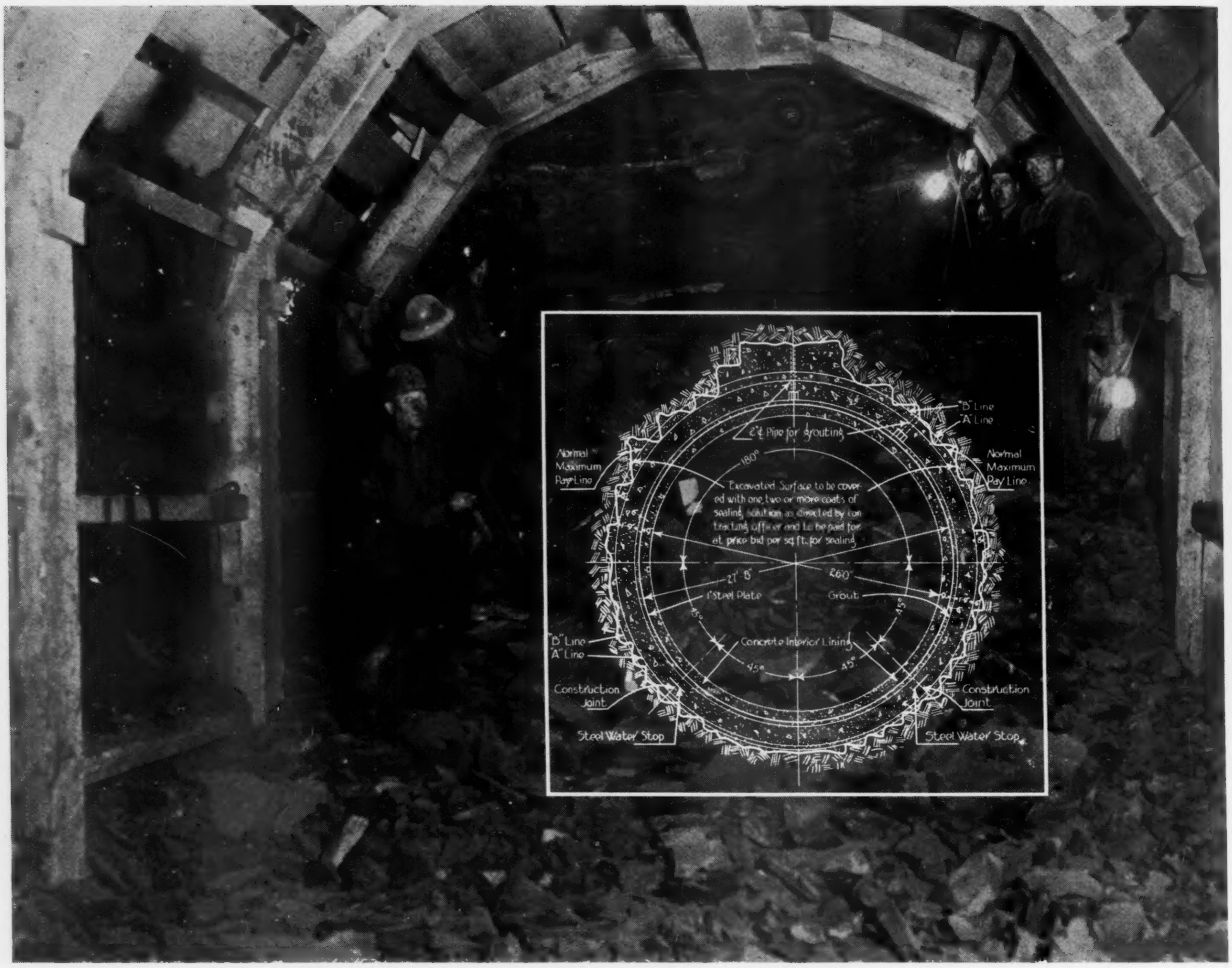


action level. It then goes into the high-pressure hydrogen line for recirculation through the reaction towers.

Because of the high temperatures and pressures involved, numerous safeguards are provided against explosions and other hazards. To prevent the formation of explosive compounds through the admixture of hydrogen and oxygen, the hydrogen holder is equipped with signals which call attention to high levels, which might lead to the escape of contained gas, and to low pressures, which might permit atmospheric oxygen to be drawn into it. On the compressor suction line is a recorder-alarm which gives warning the instant the oxygen content of the gas rises above 0.2 per cent.

Although current interest in hydrogenation in the United States is limited to the application herein described, its future possibilities are almost endless. When the petroleum from our wells diminishes to a point below our needs, a suitable substitute can be derived by hydrogenating coal and oil shale, of which latter we have enormous reserves. In times of national emergency, the plants already established could be converted readily into manufactories of ammonia for the production of nitric acid to be used in the making of necessary explosives.

It is claimed that the original research in the field of hydrogenation, both here and abroad, constitutes one of the most expensive process developments ever undertaken. The sum invested in it by the Standard Oil Company, although it never has been officially stated, is estimated to be at least $25,000,000. Control of the patents on the process is vested in several organizations, each with its own territorial allotments. The holding concern in the United States is Hydro Patents Company, which pays royalty on the process to the parent organization, Standard-I. G. Stock in the patents company, which carries with it the right to use the process, was offered to all refiners of sufficient size to make them potential users of hydrogenation. Fourteen concerns, aside from the Standard Oil Development Company (acting for the Standard Oil Company, New Jersey), subscribed to stock. Thus far, however, largely because petroleum has been plentiful during the past few years, none of these has actually applied the process.



AFTER A BLAST

A view of the heading in Pilot Tunnel No. 4, showing the manner in which the Bearpaw shale breaks. Note the heavy timbering extending right up to the face, and the bituminous protective coating on the exposed surfaces at the left. The surprinted sketch is a cross section of a full-size tunnel, including details of the concrete lining with embedded steel pipe.

Fort Peck Dam

Part 3—Diversion Tunnels and Spillway

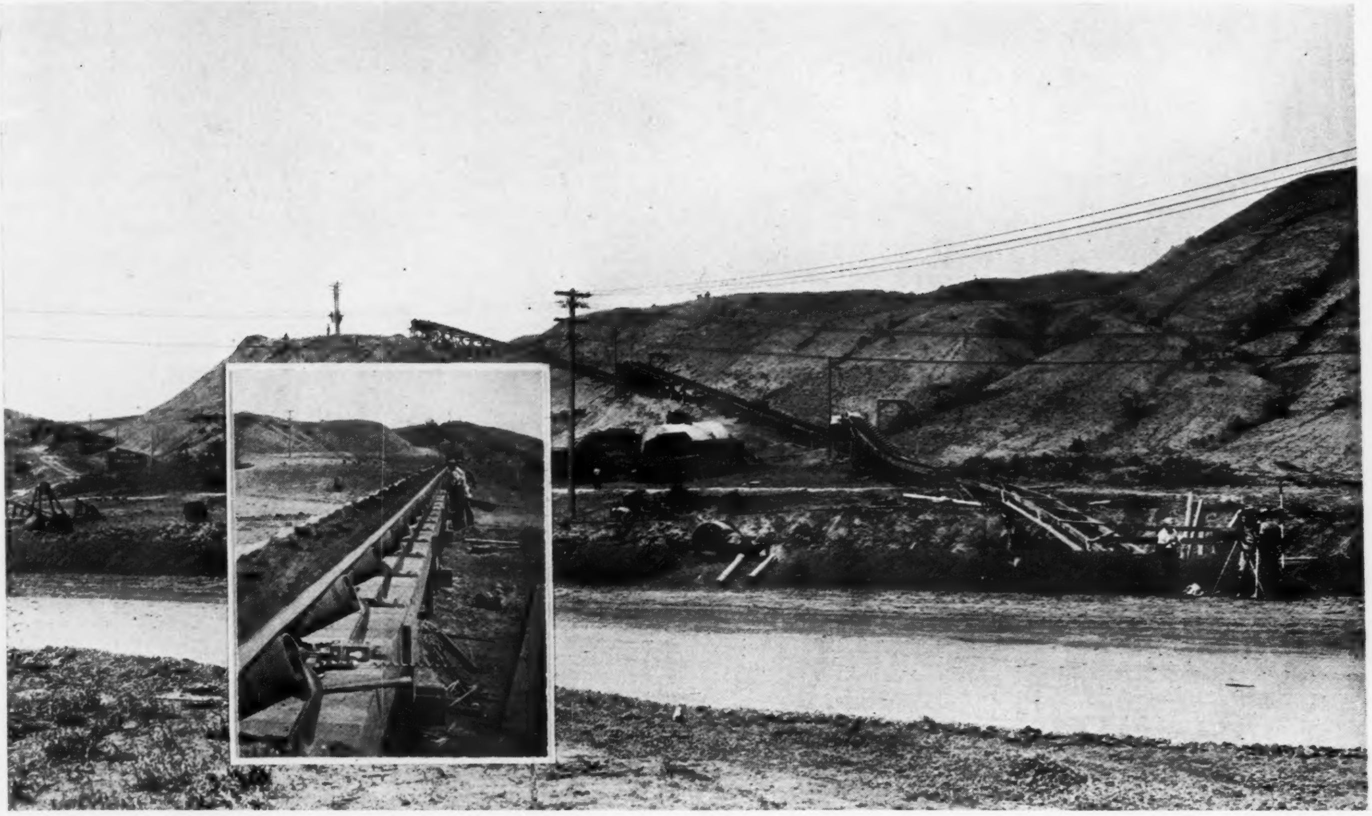
HAROLD O'CONNELL

OF THE many construction activities entering into the building of Fort Peck Dam, the driving of the four diversion tunnels is one of the most interesting.

As previously noted, the Bearpaw-shale formation underlying the Missouri River at the dam site is of great practical importance. While the presence of the shale near the surface has favorably influenced the design and execution of every major unit of the project, it has also called upon the builders to take precautions not usually necessary with bedrock—for example, to employ surface-sealing methods for controlling the tendency of freshly exposed shale cuts to dry out and disintegrate.

An accompanying drawing shows where the four diversion tunnels will pass through the east abutment of the dam. They will be circular in section, and will be excavated approximately 32 feet 2 inches in diameter. They are to be driven in two stages. The first stage, which is now in progress, consists of driving a pilot bore 14 feet high by 16 feet wide, with arch roof, at the bottom center line of each tunnel. This work is being conducted entirely from the upstream portals. The second stage will be the enlarging of the pilot bores to full size.

At the beginning of tunneling operations use was made of an electric shale saw, constructed along the lines of the machines employed in coal mines for undercutting. This saw cut the semicircular section of the pilot-tunnel heading. Because of the restricted working space and the difficulties attendant upon operations in the pilot tunnels, these machines were set aside for service later in the enlargement of the tunnels. Conventional tunnel-driving methods are now practiced. "Jackhamers," with 12-foot auger-type drill steels, are used to place blast holes in the headings. Unusual speed has been made in this way, with a record-breaking drive of 1,508 feet in No. 3 Tunnel in a single month of 29½ working days. This achievement becomes even more striking when it is considered that continuous timbering is required for protection against the fall of roof shale. Throughout this particular section the shale contains seams of bentonite. This



DISPOSAL OF MUCK

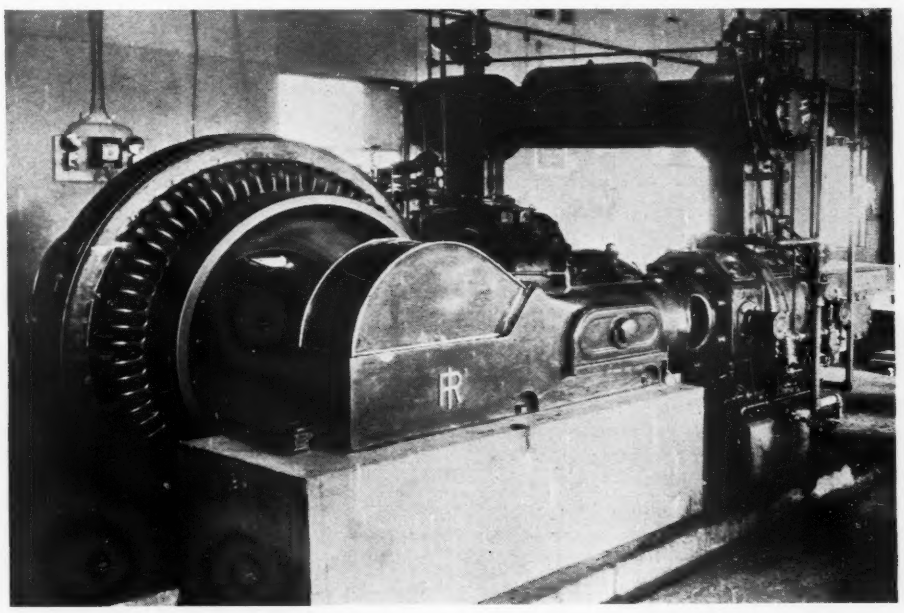
The series belt-conveyor system is the final link in the equipment provided for the movement of tunnel muck to the spoil area. The larger view shows the downstream-portal conveyor during construction, while the inset is a close-up of a section of the upstream-portal conveyor carrying the first load of muck. Both of these systems were housed over with timber structures during the winter operations.

weak, rather loose material has a low coefficient of friction when wet and breaks up the solid shale deposits and increases the hazards of tunnel driving.

An important factor which complicates tunneling at Fort Peck is the tendency of the shale to slack upon exposure to the air. Since this is caused mainly by the drying out of the material, every effort is made to maintain a high relative humidity in the tunnels. Compressed-air atomizer spray heads, at 200-foot intervals along the tunnels, are employed for this purpose, and a relative humidity of more than 90 per cent is maintained. The year-round temperature within the tunnels is approximately 43°F. A final precaution to prevent the shale from slacking is the air-spraying of all freshly exposed surfaces with a protective bituminous coating. Shale which was thus treated in an experimental tunnel shows no signs of deterioration after one year of exposure.

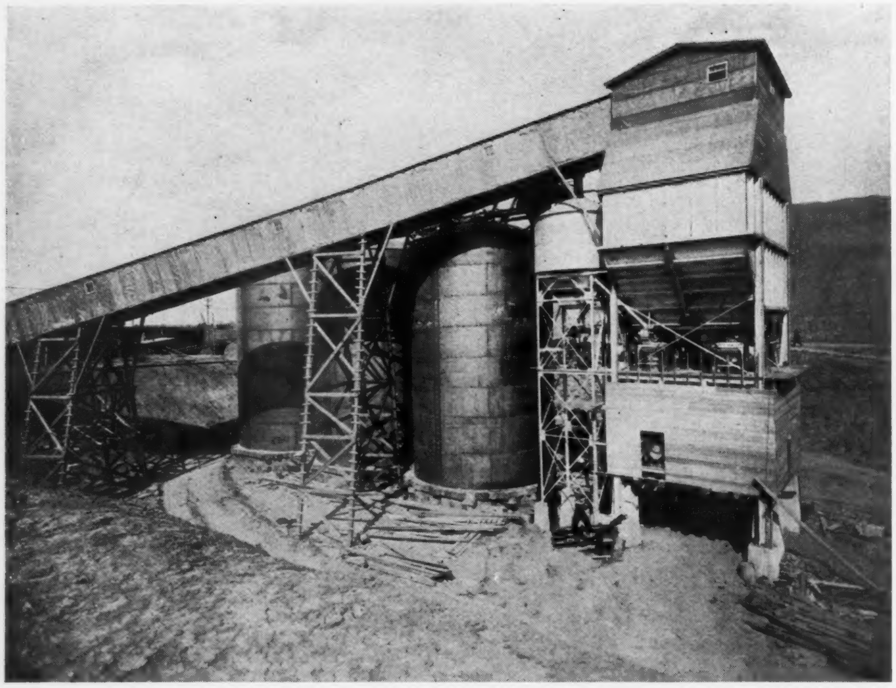
Disposition of tunnel muck is made in an unusual way. An elevating mucking machine clears the heading after each blast, placing the material on a loading gantry. It is then loaded into 3-yard mine cars and hauled to the tunnel entrances by battery-electric mine locomotives drawing 5-car trains. There it is dumped into a crusher, from which a long 36-inch belt-conveyor system carries it to a stacker at the spoil area nearly half a mile from the portals. Ventilation within the tunnels is accomplished by the use of eight 15-hp. Ventair mine blowers connected to long ventilating lines. Eight low-pressure fans with short lengths of Ventubes are also in service.

The finished tunnels will be 26 feet in diameter. The thickness of the lining is to be 3 feet 1 inch inside the theoretical excavated diameter—the contractors being paid for all material placed in a further circular zone of variable thickness up to 8 inches that is allowed for overbreak of the shale beyond the outside line. The pouring of an initial outer layer of concrete, 21 inches thick, will be carried on simultane-



COMPRESSED-AIR SUPPLY

One of two Class PRE, 2-stage compressors which supply air for tunnel driving, tunnel-portal construction, and for other work being done by the Mason & Walsh Company.



CONCRETE PLANT AND AGGREGATE STORAGE

Practically all the concrete for the lining of the diversion tunnels will be mixed in the plant shown at the top. The Government is supplying the contractors with all the sand and gravel required. These materials are brought in on the Government's 13-mile railroad spur and stored by a modern stock-piling system, as illustrated in the lower picture. Fort Peck is across the river, in the distance.

ously with the enlarging operations, it being specified that concreting shall follow final excavating at any point within fourteen days. The diameter inside this lining will be 28 feet 8 inches. At this stage there will be installed a steel pipe of 1-inch wall thickness and of an outside diameter of 27 feet 8 inches. It will be brought into the tunnels in sections which will be welded together in position. The 6-inch annular space between its outer wall and the inner surface of the concrete lining previously placed will be filled with grout. A 9-inch concrete lining within the pipe will serve to cover internal channel stiffening rings and to provide a smooth surface for the flowing water. The laying of the steel pipe and all subsequent lining will be done under a later contract.

Coincident with the driving of the diversion tunnels, shafts for the control-valve structures are being sunk from the surface of the east abutment and at a point slightly upstream from the axis of the dam. Control of the flow through the tunnels will be effected by ring gates located in the tunnels and at the bottoms of these 50-foot (finished diameter) vertical shafts. At these points the shafts and tunnels will also be lined with concrete heavily reinforced in each case with a steel shell and auxiliary I-beam construction to bear the load of the respective vertical shaft upon the tunnel structure.

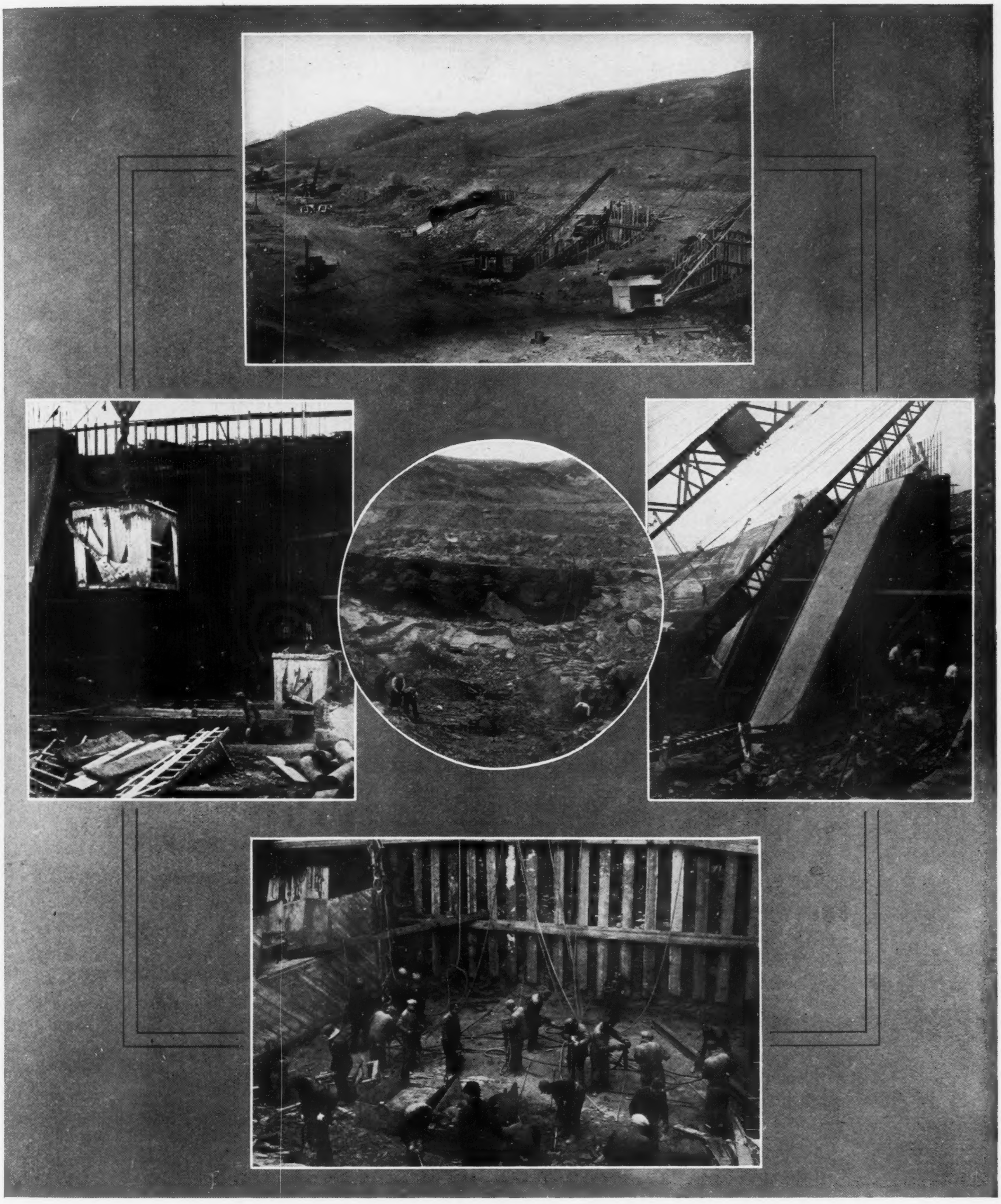
Just upstream from each control structure will be additional rectangular shafts for emergency stop-log gates. At the downstream portals, where the tunnels will emerge from the Bearpaw-shale buttes, the solid formation overhead is not thick enough to insure a satisfactory roof above the headings. This situation has made it advisable to set large blocks of reinforced concrete slightly upstream from the portals themselves. These will serve as headblocks, and behind them the tunnels will be placed in open cuts.

The lower-portal headwall will be 70 feet high from the top to the bottom of the key trench. It will be 1,000 feet in length and pierced by the tunnel openings at four points. A raceway to carry the tunnel discharge will be bounded by side retaining walls 620 feet and 870 feet long, respectively, and will have a reinforced-concrete floor 3 feet thick. Some 153,000 cubic yards of concrete and 4,145 tons of steel will be required for the headwall and the raceway. Concreting operations were carried on throughout the winter months at the lower tunnel portals. Temperatures dropped as low as −36°F. Salamanders, live steam, and protective coverings over green concrete were successfully employed for this work.

The finished tunnels will have an average length of 6,160 feet, the longest being 7,254 feet, the shortest 5,379 feet. Their construction will require approximately 18,000 tons of steel and 600,000 cubic yards of concrete. About 2,825,000 cubic yards of excavation will be necessary. More than four miles of pilot tunneling has been completed without one fatal accident having occurred inside any tunnel. No. 1 Pilot Tunnel was holed through on March 28, 1935.

After serving their initial function of bypassing the waters of the Missouri River around the area in which the hydraulic fill for Fort Peck Dam is being built up, the diversion tunnels will effect the necessary control of the water released to maintain a depth of from 8 to 9 feet in the lower navigable channel of the river. A measured quantity of water will be discharged continually to supply the requirements of towns below the dam. Estimates based upon that quantity indicate that 12,000 kw. of primary or continuous electric power can be generated. To obtain this amount of continuous power it will be necessary to install water turbines capable of developing 50,000 kw. under a normal head of 150 feet. With such an installation it will be possible to produce 220,210,000 kwhrs. of secondary power per year. By thus making inexpensive power available for domestic and low-head pumping purposes, a lasting boon will be bestowed upon the surrounding territory.

The total discharge capacity of the four tunnels at full head will be 85,000 cubic feet per second, an amount considerably less than the maximum flood on record—154.000 cubic feet per second—which passed the site of the dam in June, 1908.



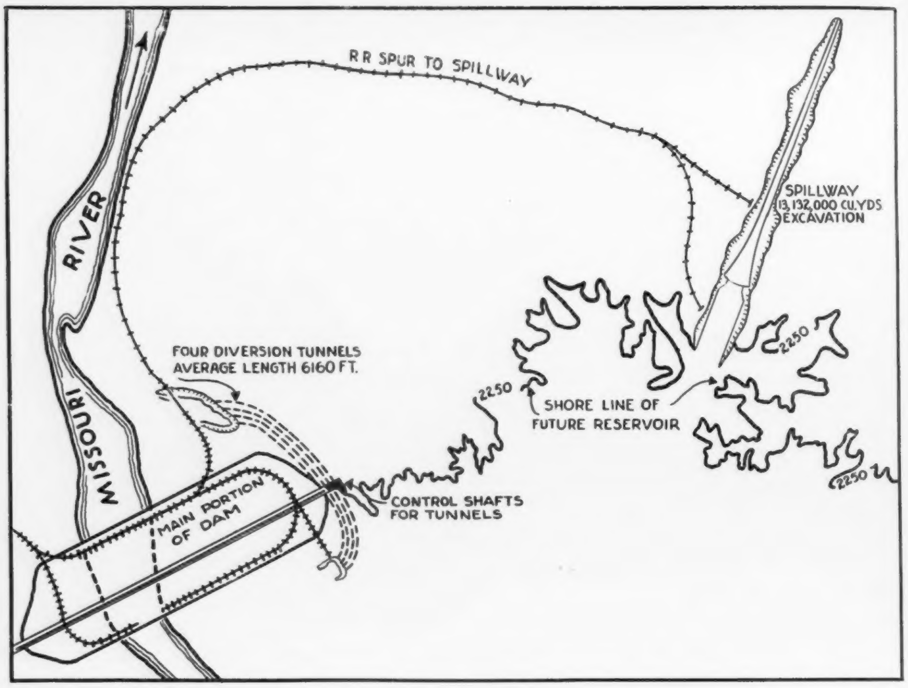
HEADWALL CONSTRUCTION AT LOWER-TUNNEL PORTALS

A headwall, several hundred feet long, is being erected to connect the lower portals of the four diversion tunnels. These pictures show the beginning of the construction. The wall will be composed of unit blocks of reinforced concrete, keyed one to another. After the hillside immediately above the headwall site had been trimmed off, the underlying shale was line-drilled at various points preparatory to the placing of the blocks. As will be noted in the picture of one of these points (circle), the shale face was sprayed with a bituminous coating to prevent spalling. The general area where the headwall will rise is seen at the top. The views at either side and at the bottom show drilling and concreting operations. The area directly in front of the headwall will be paved with a 3-foot layer of reinforced concrete.

So as to be prepared in the event of a similar flow, which might occur with the reservoir full of water, a spillway of large capacity is being constructed.

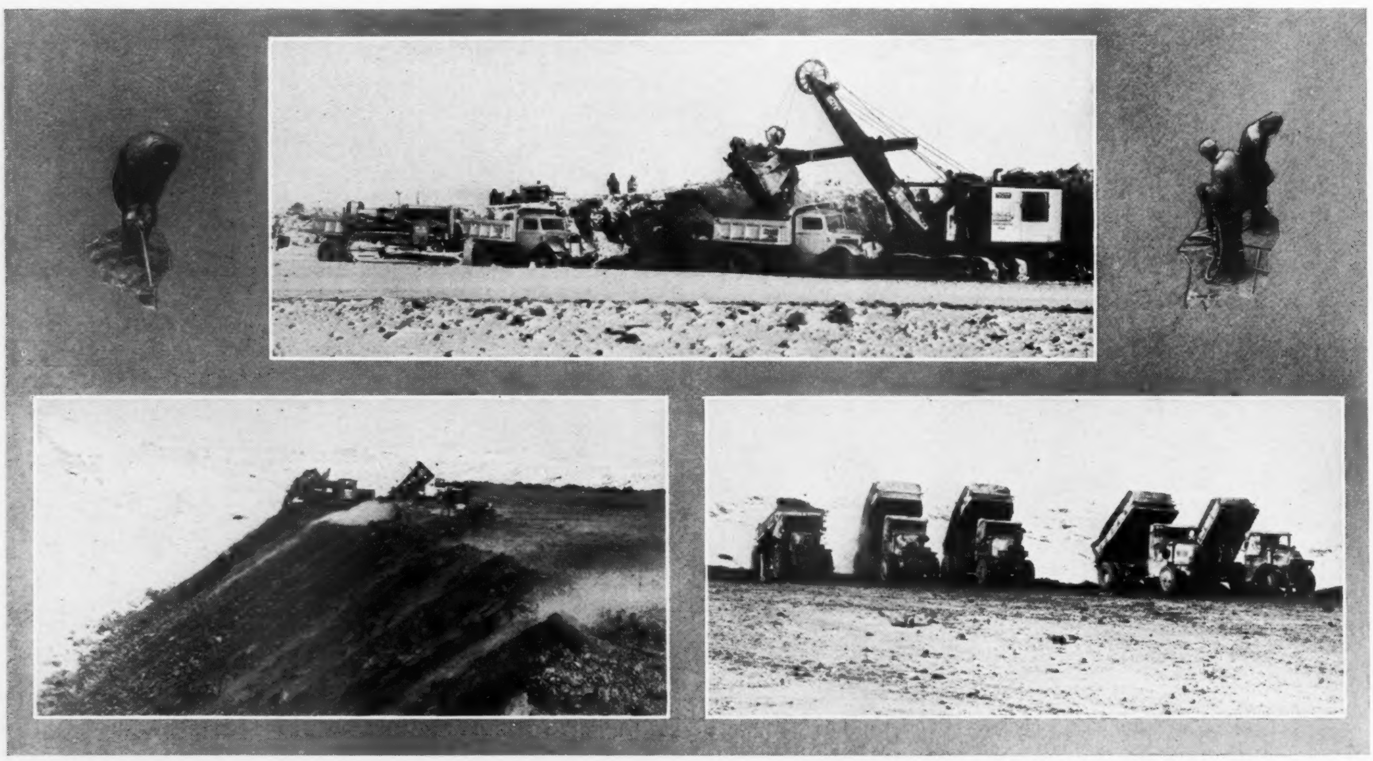
As a result of extensive and exhaustive studies, a spillway was designed with a discharge capacity of 254,000 cubic feet per second at normal pool elevation. Operated in connection with the diversion tunnels, this spillway will adequately meet the conditions of the hypothetical maximum flood.

A favorable site in the form of a coulee in the east-bank hills has been chosen for the spillway. Excavating at the end of this coulee is now in progress, and will involve the removal of some 13,000,000 cubic yards of material. About half of this amount will be taken from the underlying shale beds. Compressed-air tools and conventional blasting methods are being used in its removal. At present, fifteen diesel shovels and draglines are at work day and night, and more than 100 six-yard trucks are plying the contractors' roads from the excavation points to spoil areas. An unusually dry summer season in 1934 left so little moisture in the ground in this vicinity that the severe freezing temperatures of the past winter have not materially halted operations on the spillway excavation—the shovels being able to handle both surface and underlying material. When this work is completed, the lining of the channel below the gate structure will begin. This will be of reinforced concrete, supplemented by a bituminous apron at the reservoir end to form the approach lining.



MAP SHOWING LOCATION OF TUNNELS AND SPILLWAY

The spillway-gate structure will be of concrete. There will be sixteen Stoney gates, 40 feet wide by 25 feet high. The total width of this structure will be 700 feet, but the concrete channel carrying the water spilled through the gates will narrow down to a width of 130 feet at the lower river-level end. An entrance velocity of 24 feet per second is expected, increasing to 96 feet per second at the outlet end. About 290,000 cubic yards of concrete will be placed in the gate structure, the lining, and the cut-off wall at the river discharge end, while more than 11,000 tons of steel reinforcing will be required for the lining.



WINTER EXCAVATING FOR SPILLWAY

Excavating for the spillway was carried on night and day during the past winter by Spillway Builders, Inc., contractors for the upper part of the channel, and by the Martin Wunderlich Company, at the discharge end. This work involves the removal of more than 13,000,000 cubic yards of material, much of which is consolidated shale which requires drilling and blasting. Fifteen shovels and draglines and more than 100 trucks are operating continuously.

COBALT IN 1925

A panorama from the dump of the McKinley-Darragh Mine. Cobalt Lake is on the left. The Nipissing and other famous producers are in the background. Cobalt stands unique among Canadian mining camps, having retained throughout its career a distinctive color and character that somehow set it apart. The town sprawled unbeautifully among the mines, and the rock beneath the streets became honeycombed with drifts and crosscuts. The camp flared up quickly, and after a somewhat brief span of glory died down.

Thirty Years of Canadian Mining

Part 2—Cobalt

R. C. ROWE

THE rush to Cobalt was undoubtedly one of the most lurid in the history of mining. Men came from all parts of Canada and the world. Some of them knew a great deal about mining, and a lot of them knew nothing. There were prospectors from the West, mining men from older districts, and hammersmen trained in the phosphate pits of the Lievre, laborers and university graduates, mining engineers, and clerks from the offices of cities. Almost overnight the town sprang into existence, and it grew so fast that its appearance seemed to change almost daily.

Like all new camps, Cobalt was rough and tough, but it was not particularly vicious. The large numbers of men concentrated there were drawn from every level of society; but there was very little lawlessness. This was probably attributable to the fact that the elements of organized effort followed almost on the heels of the pioneers. Once the rush had started, it was a rush of capital as well as of men; and, under the impetus of the two, the district was carried forward on a wave of optimism at such a rate that those concerned had little time for anything but the contemplation of their own affairs.

The whole character of the Cobalt deposits lent itself to the encouragement of a period of unrestrained optimism. Unthought of wealth was there for everyone to see. Any casual observer could stroll over to one of a dozen veins and watch fortunes being blasted out. It was all so elementary—silver was money, and it could be seen in chunks. True, it was not to be found in every calcite-filled fissure; but it was in some, and therefore it might be in all of them. Stories that tickled the spine and made the hair curl were being told in various mentionable and unmentionable places in Cobalt. "They were taking out stuff running 12,000 ounces to the ton at the Little Silver." Someone else had struck a vein of silver "that was so solid that hand steel wouldn't cut it"; and over at some other place "the vein was over three feet wide and still widenin'." Facts became the basis for lurid embellishment, and stories grew in the telling as snowballs grow when rolled down hill. When it is remembered that the world had never heard of anything just like Cobalt before, it can be easily imagined that no yarn was too fantastic to find some believers. As a consequence, the attention of the whole world was focused on the region, and capital

TYPICAL PROSPECTORS

Men such as these—men for whom the cities have little appeal—discovered most of Canada's early mines. Nowadays, the search for minera's is often organized and well financed; but the individual prospector, striking out on his own, is still an important factor.

"SILVER SIDEWALK"
Cobalt inflamed the imagination because so much of its mineral wealth was visible. The trenchlike pit shown here marks the site from which was removed a rich vein of silver that extended to the surface. It was a part of the Old Lawson Mine.

began to flow in. As a flame attracts the moth, so the stories of these silver veins of the North drew the good and the bad in finance, and a wave of promotion set in.

The tide of promotions is shown by the incorporations. In 1904 there were four, among them being the famous Nipissing Mining Company. In 1905 there were 43. In 1906 there were 203; and eventually the total exceeded 600. Every foot of the country was staked for miles, and optimism and money ran riot. Men staked claims in the morning and sold them that evening. Properties were traded in like horses and changed hands as rapidly and as often. Men without the price of a meal today were wealthy tomorrow, and what they got for their claims lost nothing in the telling.

And so all men in the district dreamed of riches. Some of them got them and some of them did not; but the hopes and the dreams kept luring men to the region, and they spread over the country for all the world like a cloud of locusts. They spread south into South Lorrain and discovered more silver, the most important strike being the Keeley Mine. They spread north and found gold at Larder Lake and silver at Gowganda and Elk Lake, and farther north again made greater discoveries in gold that will have their place in a later part of this chronicle. These facts are mentioned because the wave of optimism that swept over Cobalt and resulted in so much financial quackery served a purpose which, though it was not discernible at the time, was very valuable to Canada. The North became the land of hope—a place where fortune possibly awaited any man—and the adventure ground for the young men of Canada. It has never lost this distinction in the minds of Canadians; and it is this fact that has led to its steady development and has given to the rest of the country great prosperity.

Turning once again to a consideration of those hectic early days in Cobalt, we find a scene of feverish activity. Thousands of men were at work, stripping and trenching. Headframes sprang up everywhere, and the clatter of steam drills hiccuped amid the hills. Those that had properties were anxious to determine whether they had silver; and those that had it were anxious to get it out and obtain good money for it. There was a steady stream of supplies and equipment from the South because men had to be fed and housed, for the seasons of the North are formidable and wait on no man's pleasure, and the Town of Cobalt grew and sprawled itself unbeautifully along the shores of the lake. It grew too fast and was too close to realities to venture far into the realm of beautification: it was concerned simply with the elementals of housing and covering in a somewhat rigorous climate.

Then, in 1907, came the recession of the wave of promotion which left a lot of misery and ruined hopes. It was lamentable; but the winnowing of the grain from the chaff went on unabated and the fundamental soundness of the camp began to assert itself. Under all the froth and bubbles of the orgy of promotion and wildcatting the steady work of development by organized forces had been going on, and Cobalt was rapidly taking its place as one of the world's great silver-mining districts. The story of this development is plainly told in the production figures.

In 1905 the output of silver at Cobalt was 2,451,356 ounces, and in 1906 it was 5,401,766 ounces, or more than twice as much. In 1907 it was 10,023,311 ounces, again almost double, and 1908 once more saw the production of the previous year nearly multiplied by two with a total of 19,437,875 ounces. In 1909 the output was 25,658,683 ounces, and by 1911 it reached a record of 29,989,893 ounces. In 1911 the production started to recede slowly and continued to fall off slightly

WHERE IT ALL STARTED
One of the unconfirmed stories of Cobalt's discovery has it that a blacksmith named Fred LaRose, employed by railroad builders, threw a piece of steel at a passing fox and found, upon retrieving it, that it had gouged some silver ore from a rock it struck. Thus began the LaRose Mine pictured here.

A MINE AT LORRAIN

Lorrain, to the south of Cobalt, was one of the latter's many offshoots. Several mines, most of them now deserted, were developed there. Among them was the Frontier, which is shown as it appeared in 1925 when the district was still fairly active.

until 1913, when it began to taper sharply. In 1933 the output at Cobalt was only 1,558,944 ounces, or nearly 900,000 ounces less than in 1904. Up to the end of 1933 the aggregate production of silver at Cobalt proper was 373,503,068 ounces, and at Cobalt and outlying districts such as South Lorrain, Gowganda, etc., it amounted to 420,741,513 ounces. Its total value was nearly $260,000,000. In addition, some $25,000,000 worth of cobalt was obtained.

Naturally, in the earlier days of the camp attention was centered on the high-grade veins; but it soon became apparent that huge reserves of silver were locked up in lower-grade ores. Treatment plants for the concentration of the silver ores came into being rapidly. The first gravity-concentration plant was set up in 1907. Concentrates, like high-grade ores, were shipped to outside points for final treatment. Cyanidation was originally tried in 1908 at the Buffalo, but was not very successful, and the first really effective application of the method was made at the O'Brien in 1909. Aluminium dust was used for precipitating. Later, flotation was introduced into the camp, and either cyanidation or flotation as an adjunct to gravity concentration became general practice throughout the district.

In the good old days, when veins running more than 10,000 ounces to the ton were common, management was inclined to be extravagant; but as time went on, and values began to drop, Cobalt settled down to the serious contemplation of its problems, with the result that mining and milling methods became highly efficient, and there was produced a great crop of economically minded mining engineers whose training in the Cobalt District has had its effect upon mining throughout Canada.

Viewed in a general way, Cobalt cannot be termed a long-lived camp. It flared up quickly, drawing the eyes of the world to it by its spectacular character, and after a somewhat brief span of glory it died down. Its veins were not deep seated; but what they lacked in size and extent they made up in richness, and they poured great sums of money into the economic structure of Canada in a few years. But they did more than that. Those extraordinary veins with their loads of wealth were like a beacon showing the way to a new land with infinite possibilities and promise. How the promise of the years has been fulfilled will be told later; but here we may venture the opinion that, when the final history of whatever destiny Canada may eventually achieve is written, the District of Cobalt will be remembered because it pointed the way rather than because it directly contributed so heavily to the material prosperity of the entire country.

IV

Which Treats Mostly of Men

"No rose but fades: no glory but must pass."
—Masefield

NAMES drift through the saga of Cobalt like old songs through the mellow twilight of a summer's evening. There are names of men who have made their mark in Canadian mining, and names of men who are but a memory now; but one and all they have contributed something in example and accomplishment to Canada that has made even the poorest of us richer.

As we gaze back at the great spectacle of men and events that was Cobalt, perhaps the figure that comes first to our notice is that of Dr. Willet G. Miller. He appears before us as a great figure of a man whose scrupulous honesty of purpose and scientific viewpoint make him stand peculiarly aloof from the hurly-burly of

HAILEYBURY

It was in Haileybury that Dr. W. G. Miller, provincial geologist, showed specimens from Fred LaRose's prospect on a night in November, 1903, and thereby precipitated a rush of prospectors that resulted in many important discoveries. Although a neighbor of Cobalt, Haileybury antedated it.

PICTURE ROCK

Ore running 10,000 ounces to the ton in silver was not unusual in Cobalt's heyday. This picture shows a mass of almost solid metal from the Reeve-Dobie Mine at Gowganda.

that hectic new-born camp. Yet, though he was detached from the feverish excitement of his surroundings, he was curiously human and gave freely of his great store of knowledge to all and sundry who sought him, and their number was legion. He was as much a part of Cobalt as the silver that made it and the pre-Cambrian that bore it. To his memory there was erected at Cobalt station a cairn carrying a plaque; and tributes to his achievements are scattered here and there. But perhaps the greatest tribute of all is the warm memory with which he is held in the hearts of so many men, and the affection with which they speak his name.

Linked with Doctor Miller in the story of Cobalt is Cyril W. Knight, who was a young man then and assistant to the great geologist. He also moved in and out of the Cobalt picture for some years, and finally became a very definite part of it when he was made chief geologist of the Nipissing Mining Company. When that famous silver producer began to decline he became the head of an exploration and development company that has spread its operations over all Canada.

The Nipissing Company turned out several men who were to play a leading *rôle* in mining affairs in other sections of Canada. Among them is Hugh Park, who was manager of the company for many years and who led its activities into other areas. There was also Harry A. Kee, who was superintendent at Nipissing for a long time and who later became manager of the Kerr Lake Mine. It was Kee who subsequently drove down the first real deep-level shaft of northern Ontario. That was at the McIntyre Porcupine; and he sank the shaft from surface to 4,000 feet. Still later he sank the Mond Nickel Company's shaft on the great Frood ore body. That was in the days before the two great nickel companies became one. It was he who stepped into the great field directorship of Northern Aerial Minerals Exploration when poor Gordon Duncan died; and now he is making his mark in opening up mines in northern Quebec. Another Nipissing man who has had much to do with mining development in other sections is E. V. Neelands, chief field engineer for Ventures Limited.

We have already mentioned the Timmins brothers, Noah and Henry; the McMartin brothers, Duncan and John; and D. A. Dunlop, who bought the claims of La Rose and found fortune. The queer workings of fate threw them into a partnership that had far-reaching effects upon mining progress in Canada. It was a great partnership, splendid in its loyalty of each to the other and unshakable in its strength; but Providence has parted what was welded in Cobalt and what all the strains of adversity could not break. The McMartin brothers are both dead, and so is Dunlop; but the Timmins interests are still carrying on what was begun in Cobalt 30 years ago. Their names will flash through other chapters of this history; but the figures of those men are a very definite part of the picture of Cobalt as we look back at it through the years. And speaking of the La Rose, we must not overlook George C. Bateman, who managed it for years and who is now secretary of the Ontario Mining Association.

It is a crowded scene that the great silver camp presents as we glance back at it, and it is hard to pick men out; but if we look closely we shall see a young man, a newly fledged graduate of Queen's, who has come to strange surroundings. He was undoubtedly as quiet and modest then as he is now, and one might easily pass him by. That young man is Alex Longwell, who helped W. G. Trethewey stake the claims that afterwards became the Trethewey Mine and the Coniagas Mine. Young Longwell was there in the interests of R. W. Leonard, who subsequently became president of the Coniagas and who donated the Leonard Medal to the Canadian Institute of Mining and Metallurgy. Alex Longwell became assistant to Mr. Leonard and has had a hand in the many things that the Coniagas has done in developing other districts.

Like so many Cobalt mines, the Coniagas produced men who have left their mark elsewhere. There is Fraser Reid, who was its manager, and who hung up a record for low costs which enabled the mine to operate long after the high-grade veins were exhausted. He is now manager of the Howey Gold Mine—where he has

METERED AIR

Much of Cobalt's compressed-air supply came from the Taylor hydraulic compressor plant at Ragged Chutes on the Montreal River. It was piped to Cobalt through a 20-inch line and sold at so much per 1,000 cubic feet. This picture, made in 1925, shows a take-off from the main line.

again made history in low costs—and also a director of other mining companies. And then there is John Redington who went from the Coniagas to the Coniaurum in Porcupine, which was an off-shoot of the old Cobalt company. And the name of Trethewey—to whose efforts the discovery of those two mines was due—has been carried forward by his son, Frank Trethewey, who has helped to develop a number of mining districts.

The lure of Cobalt attracted men of all kinds and types, even poets; and one of the most colorful figures that moved through the pageant of its history was Dr. W. H. Drummond who immortalized the French-Canadian habitant in verse. He acquired the mine that bore his name, and lived on the property in a little picturesque shack. His remarkable personality made him tremendously popular with all classes in the camp; and, so far as can be seen, he deserted the muse for the pick with a thoroughness that was characteristic of him. He did, however, break forth into verse during the time he was in Cobalt, and the following song, which does not appear in his books, was inspired by his new walk in life:

BLOOM

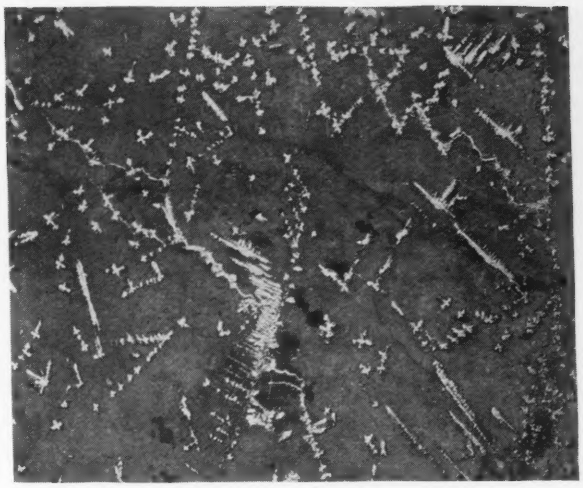
A Song of Cobalt

"Oh, the blooming cheek of beauty, tho' it's full of many a peril,
Where's the miner doesn't love it, for he thinks he knows the girl,
While the bloomer, oh, the bloomer, of emancipated She,
May it bloom and wither promptly every seventh century.

Oh, the early bloom of blossom on the apple tree in June,
Is there mortal having seen it, can forget the picture soon?
And the wine of red October where Falerian juices flow,
I have sipped the blooming beaker (in the ages long ago).

Oh, the bloom along the hillside shining bright among the trees,
When the banners of the Autumn are flung out to every breeze,
How it blazes, how it sparkles, and then shivers at a breath,
What is it when all is spoken but the awful bloom of Death?

Oh, I've watched the roses' petals, and beheld the summer sun
Dipping down behind Olympus when the great day's work was done,
But today I'm weary, weary, and the bloom I long to see
Is the bloom upon the Cobalt--that's the only bloom for me."



RICH ORE

Specimens such as this caused the feverish promotion through which Cobalt passed before it settled down to sane production. It is native silver in calcite from the Temiskaming Mine.

Doctor Drummond died in Cobalt, in the little shack on Kerr Lake, and the man who was with him when he breathed his last was the man who managed his mine, R. W. Brigstocke, who was one of the first engineers to go to Cobalt and has had a part in many mining matters since those far-off days. Now he is a consulting engineer in Toronto.

Looking again, we see another colorful figure, a young man this time, powerfully built and strong. His name is John E. Hammell—more generally known as Jack Hammell. He had come from the west coast, and got his start in Cobalt where, in a pioneer community, all the tenacity and dynamic energy that was to make him famous had full play. He flares across the succeeding years of mining history in Canada like a flaming comet across a darkened sky, and his name is associated with such mines as Flin Flon, the Howey Gold Mine, Greene Stabell, and Pickle-Crow. Some record of his accomplishments will come later in this story; but at the moment we see him, young and strong, moving amid the figures of the crowded stage of early Cobalt.

We have already referred to the natural movement from Cobalt to adjoining districts, and as we envision that movement we get a glimpse of three men trailing down into South Lorrain. Their names are Charlie Keeley, John M. Woods, and Robert T. Jowsey, and they found the Keeley Mine which had so checkered a history and which broke a bank before it really came into its own. It is probable that "Bob" Jowsey even in those days had that little humorous quirk at the corners of his mouth that has been seen since in so many places in Canada. He has played a big part in the opening up of the newer gold districts of Canada; and it was the silver veins of the Cobalt District that turned his feet into the paths that were to have so excellent an effect upon Canadian mining development. Mention of the Keeley conjures up the picture of MacIntosh

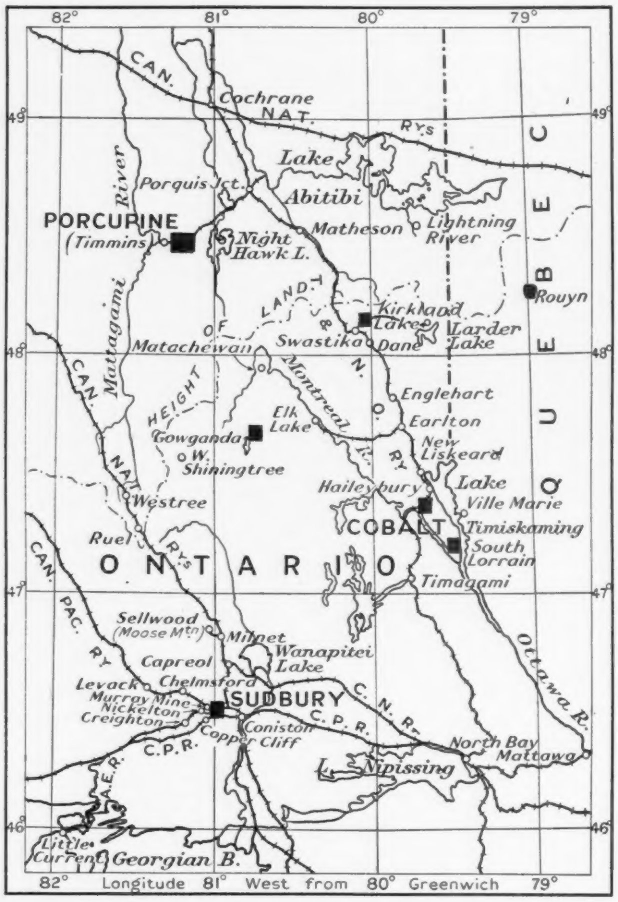
KEELEY MINE

Shaft house and mill of one of the rich properties at Silver Centre. It was discovered by Charlie Keeley, John M. Woods, and Robert T. Jowsey while prospecting out of Cobalt. The Keeley broke a bank before it eventually grew into a great producer under the skillful guidance of MacIntosh Bell.

Bell, who eventually brought that mine to the full measure of its greatness. It was MacIntosh Bell who first pointed to Great Bear Lake and who discovered lead-zinc at Great Slave Lake. He has passed from our midst, but the measure of his value to Canada remains.

As we glance over the old records we find still other names that are very familiar. The Cobalt Silver Queen had a superintendent named Robert A. Bryce. He was a young man then, but he has traveled far since those days. His vision and organizing ability have recently given us the Macassa Gold Mine, the latest lusty producer of the Kirkland Lake District. Again, the manager of the Penn Canadian Mines was another young man, Balmer Neilly, who also has traveled far. He left his manager's job to become secretary of the Ontario Mining Association, and later was made assistant to the president of McIntyre Porcupine Gold Mines, Limited. In 1933 he was president of the Canadian Institute of Mining and Metallurgy; and in those various capacities he has had a good deal to do with the progress of mining in Canada.

Tucked away in a corner we find a small note to the effect that one of the lots in the Gillies Limit, which were put up for auction by the government of Ontario after being withdrawn from staking for some years, was purchased by F. M. Connell. History does not relate what he did with it. It is fairly certain, however, that he did not do much, for that area upon which so many hopes were pinned was a definite disappointment. But no matter how little or how much it was, Connell has achieved a lot of things since, notably in northwestern Quebec and in the District of Patricia. Some record of these things will appear later; but at this stage we see him, a little shadowy perhaps, among the men of Cobalt.



HOW COBALT SPREAD

As Mr. Rowe points out, Cobalt was the cradle of Canadian mining. It provided the spark that fired the ambitions of men to seek further and to discover vast new mineral deposits. It served as a training ground for many individuals whose names have since grown illustrious, and as a proving field for technological processes. The map shows the principal mining localities in the region of which Cobalt is the center.

We could go on almost indefinitely as those figures pass before us. There was Norman Fisher, who went from silver mining in Cobalt to asbestos mining in the eastern townships of Quebec, and thence to gold mining in western Ontario. There was Sam Cohen, who took charge of a mine and discovered it was a lake. He hit on the ingenious expedient of partly draining the lake and then digging his prospecting trenches in the frozen mud left on the bottom. He found a vein, and the Crown Reserve Mine came into being. He is in California now. Then there was H. Southworth who ran the City of Cobalt Mining Company and later turned from mining engineering to selling mining equipment. He has become as well known in the latter field as he was in the former. There was also H. G. Young of Hudson Bay Mines who has had a hand in many things since his Cobalt days. It was he who brought the Howey Gold Mine, situated 180 miles from a railway, to production, and who has played a prominent *rôle* in the development of the Red Lake area generally. And there is Arthur Cole, the mining engineer of the Timiskaming & Northern Ontario Railway, who moves all through the picture of Cobalt in his quiet way—who has seen it grow to its zenith, who has watched it decline, who probably knows more about it than any other living man, who has, in fact, had a part in the whole development of the North, and who still has his headquarters in the old town.

The list would not be complete without J. P. Watson, president, and M. F. Fairlie, manager, of The Mining Corporation of Canada, which was one of the last big producers in the district to close down. They were important figures in the development of Flin Flon; and mining enterprises throughout Canada stand as evidence of the expansion that started with their Cobalt operation and as tributes to their accomplishments in the upbuilding of the mining industry of the country. And so we could go on, but the exigencies of time and space prevent us from continuing with this record of the men of Cobalt. It is a record, however, that, if carried through to its ultimate details, would be found to penetrate the economic life of Canada to the core. Names we have mentioned will appear again in subsequent parts of this chronicle; but they are given here as a background to a proper comprehension of the waves of effort that sprang from Cobalt and that resulted in the discovery and development of the gold fields which will be described in the next chapter.

Before turning from Cobalt and leaving it to its memories, it is worth noting that it acquired a certain character and atmosphere that have not been attained by any of the later towns of the North. In some odd way it always remained typical of the pioneer, and through all its rise and decline it never became commonplace. Perhaps this was due to the fact that it grew right around its mines. There were headframes amid its houses, and the dull shock of blasting could be heard and felt right under its streets, for the rock beneath it is honeycombed with drifts and crosscuts. Perhaps its architecture, with utility as its aim, was peculiarly its own, or perhaps it was an orderly disorder that in some strange way it gathered to itself.

But whatever it was, Cobalt always remained colorful and always retained a fascination that tugged at the heartstrings. There is no doubt that thousands of men have felt that pull as they looked over its lights glittering in the crystal coldness of a winter's night, or saw its shaft houses bulking black in the purple night-gloom of summer.

And now, though all its mines except one—the O'Brien—are silent, and the shaft houses are rotting, it still has that odd fascination and still is colorful. The great crowds at the station, as the train pulls in, are gone. Gone also is the pile of buildings on the hill that was the famous Nipissing, and in its place stands a blackened ruin. Gone is the feverish activity, and mines that once were world famous are now but names in the fading memories of men. Nature is cloaking the great scars left by the foraging and probing of man; but as the train rounds the curve the old tug at the heartstrings is felt, for men will look in silence through the windows, and in their silence is a tribute and a fleeting sadness at the passage of time and event.

(*To be continued*)

The Largest Dam in the Old World

Photos from India State Railways.

STREET SCENES IN MADRAS

Madras, the principal city in the part of India to which the accompanying article relates, is the third largest Indian city and the chief seaport along the eastern coast. More than 500,000 persons, of whom five-sixths are Hindus, reside there. It has several large cotton mills, dyeing and cement works, iron foundries, and cigar factories. Through the expenditure of large sums, a fine, though entirely artificial, harbor has been created. The city covers a large area, and parts of it are almost rural. In the business section is a mile-square area known as George Town. It is densely populated, and in it are to be found banks, the custom house, and various public buildings.

ONE OF the greatest dams in the world has been recently completed and put into operation in southern India. Were it not for the fact that the Boulder Dam dwarfs, by comparison, all previous works of its kind, the undertaking in point would be given wide publicity. It is the largest dam ever built in the eastern hemisphere, far exceeding the well-known Assuan structure on the Nile River. This dam is at Mettur, on the Cauvery River, in the political subdivision of Madras, the southernmost province of India. It contains slightly more than 2,000,000 cubic yards of concrete and masonry, is 5,300 feet long, has an extreme height of 214 feet above the foundations, and a maximum basal thickness of 171 feet. Its purpose is to store the flood waters of the Cauvery in order that they may be made available during dry seasons for irrigating delta lands downstream. For the distribution of the water there is being constructed an extensive system of canals. These, together with the dam and its appurtenant works, constitute what is known as the Cauvery Mettur System.

The dam is notable both for its size and for the economy with which it was built.

Its cost, including overhead charges, was 48,000,000 rupees, equivalent at par value of the rupee to $15,552,000. As the structure will impound 93,500,000,000 cubic feet (2,146,464 acre-feet) of water, this represents an outlay of $166.21 per 1,000,000 cubic feet of storage capacity, a figure which is lower than that for any other dam thus far constructed in the Old World. (Based on estimated figures, Boulder Dam, with 1,328,580,000,000 cubic feet of storage capacity, will cost about $53 per 1,000,000 cubic feet of storage).

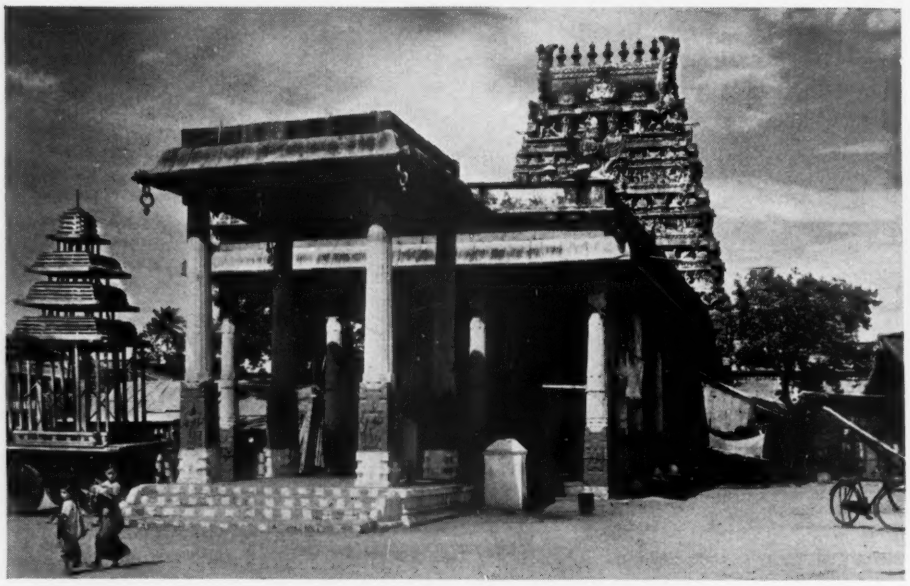
Like most large reclamation projects, the Cauvery Mettur System is the outgrowth of mature consideration. It is a coincidence that the idea of damming the Cauvery for storage purposes was first advanced just 100 years prior to the completion of the existing structure. Its originator was Sir Arthur Cotton, a British engineer and the father of irrigation in India. Although opposed during much of the time by the Madras Government, he constructed various diversion dams and canals which greatly enriched large sections. As a result of his work, Tanjore District, which had been threatened with ruin from lack of water, became payer of the largest revenue of any district in India. These accomplishments melted official criticism, and in 1858 the Madras Government referred to Mr. Cotton as a "master mind." Three years later he was knighted. He considered it possible to build a network of irrigation and navigation canals throughout India, and spent his entire life in making a beginning towards that end.

The Cauvery River rises in the Western Ghauts mountain range in the State of Mysore at an elevation of 4,400 feet above sea level, flows some 500 miles in a general southeasterly direction, and empties into the Bay of Bengal. It drains an area of 31,000 square miles. The region in which it heads is visited by heavy rains during the southwest monsoon, and the runoff is heaviest during July and early August. The middle portion of the stream serves as the drainage basin for the Mysore Plateau, where there is a fluctuating rainfall from August to October. From the Mysore Plateau the river winds through hilly country and then emerges upon the plains. It is at a site in a gorge just short of this point of emergence that Mettur Dam has been constructed. Downstream from the dam the watershed is subject to the northeast monsoon rains which sometimes produce high floods in November. As a general rule, this sequence of rainfall causes a sustained high flow of the river during the irrigating season from June to January, save for about six weeks when there is a break in the monsoon. The northeast monsoon is not dependable, however, and in the past its failure to deliver moisture regularly has at times very seriously affected the cultivation of the Cauvery delta. The Mettur Dam is designed to overcome these fluctuations by storing the surplus waters of the southwest monsoon and making them available for distribution during periods of drought.

The Cauvery delta begins approximately 100 miles upstream from the coast. At its head the river divides into two branches: the northern or main channel, which is called the Coleroon River, and the southern one, which retains the name of Cauvery. The Cauvery is the chief carrier of irrigating water; and at the bifurcation a regulatory dam spans the Coleroon to divert water, as desired, into the Cauvery. Twenty miles farther downstream the two branches again draw close together, and in that area there has been erected a dam, known as the Grand Anicut, which provides a means for discharging the surplus waters of the Cauvery into the Coleroon. It is from this point, under the current scheme, that the Grand Anicut Canal is being built to distribute water to the southwestern part of the delta. Below the Anicut, the Cauvery branches into two irrigating streams, the Cauvery and the Vennar. Each of these divides and subdivides into numerous distributaries which, with suitable regulators, supply irrigating water to about three-fourths of the Tanjore District.

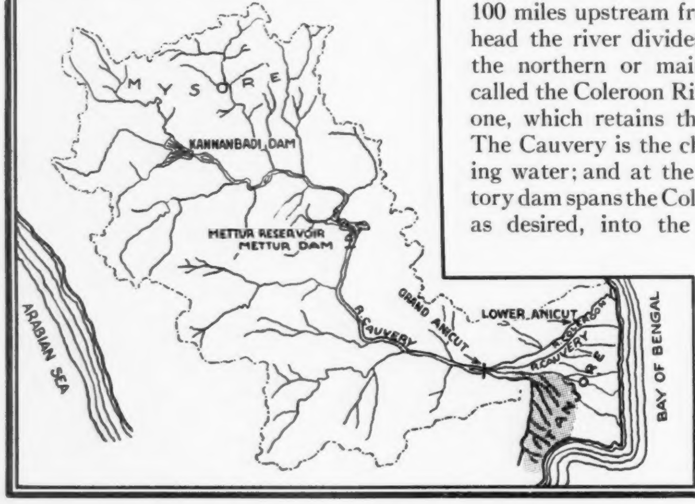
These various distributaries have come into being over a long period of time. In fact, irrigation of the Cauvery delta dates back into antiquity, and many old works remain as evidence that the early Indian rulers gave considerable attention to the distribution of water. The system, however, served to inundate the land rather than to control and to guide the flow; and for a century before the Tanjore District was taken over by the East India Company, in 1801, the works were badly neglected, with the result that many of the channels were silted up and an extensive acreage was abandoned for the want of an adequate supply of water.

One of the first concerns of the British



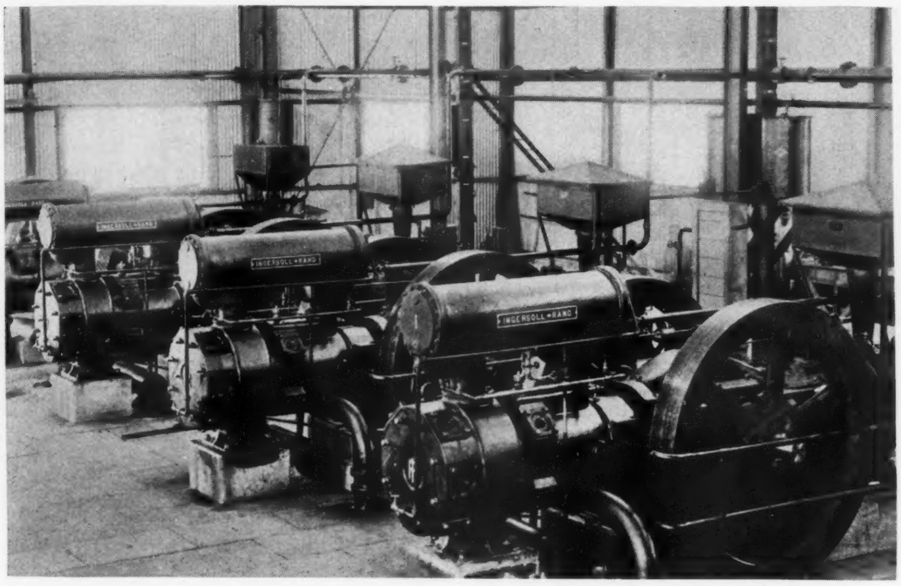
MYLAPAN TEMPLE IN MADRAS

One of the various Hindu houses of worship. Although now largely Hindu in population, Madras owes its founding to the British. Francis Day of the East India Company obtained a grant of the site in 1640 from a native ruler and established a fort there. The municipal corporation is the oldest in India. Its chief exports are hides and skins, oil seeds, cotton, chrome, and magnesite.



GENERAL LOCATION MAP

This sketch shows the catchment basin of the Cauvery River and the location of the Mettur Dam with respect to the delta lands which it is designed to irrigate. The Cauvery is about 500 miles long and, with its tributaries, drains an area of 31,000 square miles. The shaded section indicates land that will be brought under irrigation for the first time.



SOURCE OF COMPRESSED AIR

Compressed air performed diversified services at Mettur Dam, including the operation of rock drills, riveting hammers, hoists, and other pneumatic appliances. It was piped to the various points of use from two groups of stationary compressors, totaling nine units. Shown above are five Type POC-2 machines, each consisting of an oil engine direct connected to a 2-stage compressor.

Government was to rehabilitate the system. Sand was removed from channels, and scouring sluices were provided to keep them clean. While these measures helped, they were only temporarily effective, and it was not until Sir Arthur Cotton constructed the dam known as the Upper Anicut across the Coleroon to divert more water into the Cauvery that conditions were materially improved. At the same time, to compensate for the reduction in the flow of the Coleroon, another dam, the Lower Anicut, was built in that river about 70 miles farther downstream. But further trouble developed from floods that were too heavy to be controlled and that damaged the bed and banks of the Cauvery. Although these difficulties were alleviated through the construction of a dam across the Cauvery at the head of the delta and through additional regulatory structures at various points, it became apparent that a storage reservoir farther upstream, such as had been urged by Sir Arthur Cotton, was the only permanently satisfactory solution.

During the century that elapsed between the conception and the execution of the plan, numerous schemes were put forward with a view to carrying it out; but none had a real chance of adoption until Col. W. M. Ellis, in 1910, submitted a comprehensive report with detailed studies and recommendations. Even then actual construction was delayed fifteen years because the Mysore and Madras governments could not agree on the division of the water in the Cauvery.

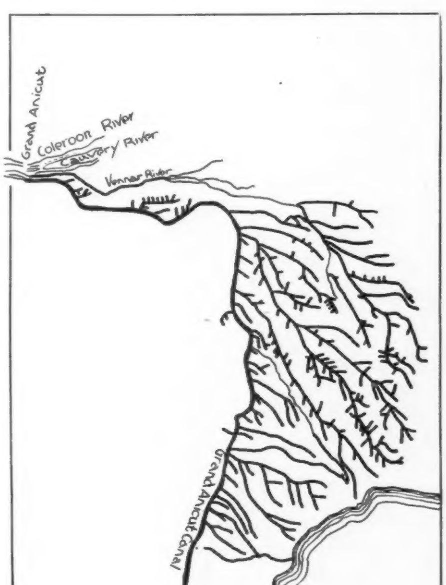
In view of what happened subsequently, this dispute actually turned out to be a great blessing, for in July of 1924, a flood of unprecedented proportions raced down the Cauvery and undoubtedly would have overtopped a dam of the dimensions that had been contemplated. That flood reached the stupendous volume of 456,000 cubic feet per second, or nearly double the highest flow previously recorded. (The greatest known flood of the Colorado River was around 300,000 cubic feet per second). Needless to say, the plans for the dam were amended in the light of that experience. Its site was changed to a point a mile farther upstream, where a saddle on one side provided for emergency-water storage. To make up for the consequent reduction in reservoir area, the height of the dam was proportionately increased. The structure, as erected, can discharge 550,000 cubic feet per second, and this is believed to insure its safety under the worst possible flood conditions.

Although actual work on the dam did not get underway until later, the start of the project was signalized on July 20, 1925, by a blast that was discharged in the presence of The Right Honorable Viscount Goschen, then governor of Madras. The undertaking involved the laying out of the Township of Mettur and the construction there of water-supply and drainage systems, as well as of the numerous dwellings, workshops, stores, offices, and other buildings that were required to carry it through to completion. These things had been accomplished early in 1927, and in the meantime excavating of the dam foundations had been started. The first concrete was poured in August, 1928, and the structure was finished five years and ten months later. The system was officially inaugurated on August 21, 1934, by Sir George Frederick Stanley, governor of the Madras Presidency.

Although the setting was an ancient one, the construction was marked by the use of modern machinery at every stage. Compressed air was a major assistant, supplying power for drilling rock in excavations and quarries, for grouting, for operating hoists and winches, for riveting, and for cleaning masonry. Nine compressors were installed, seven at one location and two at another, and the air was piped from them to the various points of use. Most of the pneumatic equipment was furnished by Ingersoll-Rand Company.

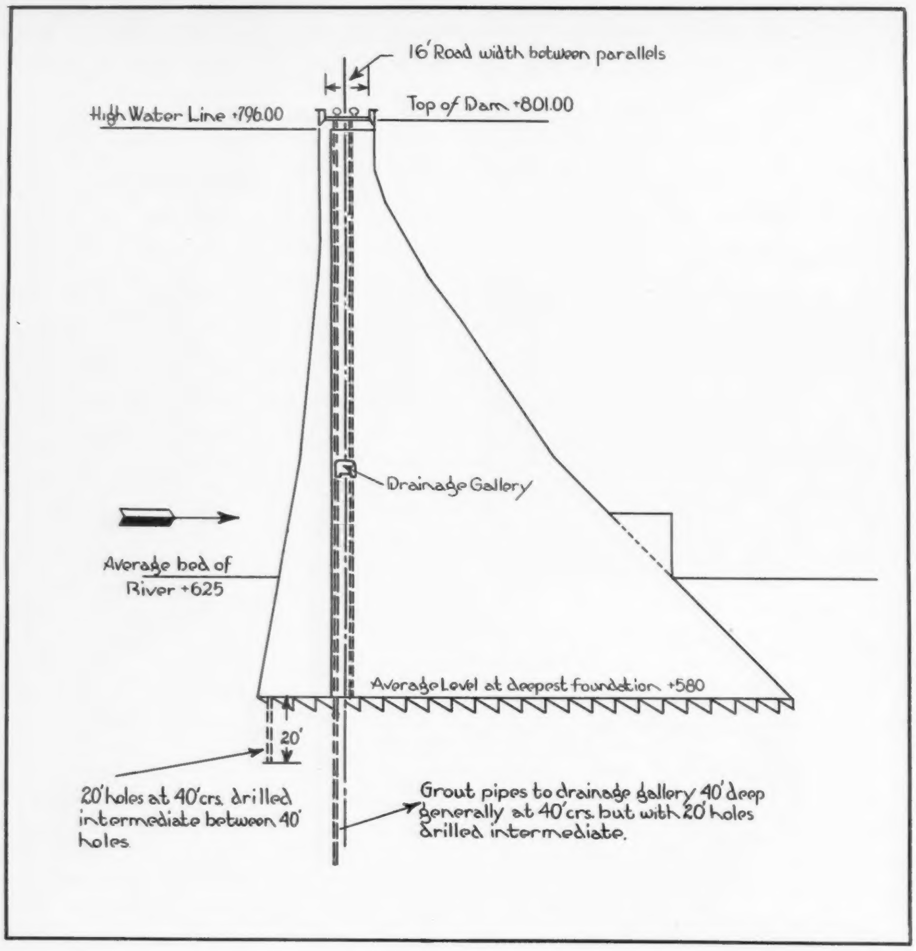
Two portable towers, each 306 feet high and mounted on 64 wheels, moved along an 80-foot-gauge track at the rear of the dam to supply concrete. Each of these was provided with two 2-cubic-yard mixers, as well as elevating machinery, and could place 840 tons of concrete daily. The towers were built by Stothert & Pitt, Limited, of Bath, England. Concrete aggregates were furnished them by three crushers, each capable of breaking 120 tons of rock an hour. These were manufactured especially for this job by Hadfields, Limited, of Sheffield, England.

The period of greatest activity on the dam was the year beginning April, 1931. During that twelvemonth a total of 682,908 cubic yards of concrete was poured. This represented 1,234,720 tons, or approx-



CANAL SYSTEM

The work of rehabilitating the old canal system and of extending it through new construction was started in 1926 and will be completed sometime this year. The Grand Anicut Canal will be 106 miles long, and from it will run branches and field channels aggregating 2,600 miles. This network of waterways will irrigate an area of 1,352,000 acres in the Tanjore District, which is one of the most productive sections of India.



SECTION OF DAM

At this point of deepest excavation the dam has a basal thickness of 171 feet. Provisions have been made in the design to permit raising the dam 10 feet at some later time to compensate for silting up of the reservoir area.

imately 34 per cent of the entire structure. The best monthly progress was made in March of 1932, when 61,388 cubic yards was placed.

For transporting materials to the dam site and about the working area there was constructed 71 miles of 2-foot-gauge track; and 38 steam locomotives and some 1,800 cars were used in this service. The cost of haulage, exclusive of depreciation charges on equipment, was about one cent per ton-mile. Except for the locomotives and some of the air compressors, all machinery was operated by electricity, and this was supplied by the Mysore Government from its Sivasamudrain power station 65 miles away.

In order to take care of expansion and contraction caused by temperature changes, the dam is divided into longitudinal sections 126 feet long—the joints of abutting sections being sealed against water leakage by means of continuous, flexible, U-shaped copper strips. On the upstream side of each strip is a diamond-shaped, reinforced-concrete staunching post that stands vertically upon nonferrous sliding plates and has its vertical faces coated with marine glue. When a joint opens, the water pressure tends to force the staunching post back against it, thus keeping it sealed. Any water that passes the post is caught by the copper strip; and, should it pass the latter, it will flow into a vertical drainage shaft on a direct line with the joint and be delivered to the drainage gallery. This gallery runs longitudinally through three-fourths of the length of the dam. In addition to the connecting vertical shafts, extending the full height of the structure at 15-foot intervals, it is also linked with the downstream face by suitable drainage outlets which, likewise, permit access to the main gallery for inspection purposes. To insure watertight foundations, closely spaced holes were drilled the full length of the upstream face, and through them grout was introduced with high-pressure air to the point of refusal.

The Mettur Reservoir will have an extreme length of 33 miles, a surface area of 59¼ square miles, and a shore line of 180 miles. Provision is made for releasing water at any one of three levels. From June to September, when the river flow is greatest, it is expected that the reservoir will be full, and then the spillways will be utilized for discharge purposes. These latter are fitted with sixteen gates, each measuring 60x20 feet. When the water level falls below elevation 774, the upper of two sets of sluices will serve to release the volume needed for irrigation. These sluices have eight gates, each 10½x16 feet. It is not believed that the water level will fall below elevation 735 oftener than once in ten years; but when this does happen, the lower sluices, controlled by five 7x14-foot gates, can be opened so as to insure water to the delta lands below. At a point in the dam 5 feet above the original river bed are outlet works for the supply of water to four hydro-generators which probably will be installed later. These will operate under a maximum head of 160 feet and will be capable of generating up to 49,000 hp., their sustained capacity depending upon the variation in river flow from year to year. All these outlet works are equipped for electrical operation with simple push-button control, but also can be worked by hand.

It is expected that the reservoir will have a decided influence upon climatic conditions in the surrounding region. It is known that it will reduce the maximum summer temperature but increase the humidity, and the great expanse of marginal waters may have an ill effect upon the prevalence of malaria.

The canal system, which will provide for a wider and more efficient distribution of water, was started in 1926, and a good part of it was available for use during 1933. It is scheduled to be completed during 1935. The main canal takes off at the Grand Anicut, and will be 106 miles long. From it will run branches and distributaries totaling 694 miles in length, and connecting with these will be field channels aggregating 1,904 miles. The estimated cost of the system is approximately $6,500,000. For 23 miles of its course the main canal was excavated by two large diesel-electric draglines. These were supplied by Ruston-Hornsby, Limited, and cost nearly $100,000 each.

This canal system will furnish water for the irrigation of 1,352,000 acres, all in the Tanjore District. Of this area, 301,000 acres represent land which was previously not supplied with water and consist of 196,000 acres of single-crop and 105,000 acres of double-crop land. Besides, the new works will allow two crops to be raised on 70,000 acres which formerly produced but one crop. The cost of the undertaking per acre of new irrigation will be about $21.50.

The prospects are that the indirect benefits of the development will be great. The general prosperity of the region affected will be increased, and this will serve as a stimulus to roadbuilding, industrial activity, and government revenue. According to estimates, the entire enterprise will yield a return of 6 per cent on a total investment of approximately $22,000,0000.

The work is being conducted by the Public Works Department of Madras, with R. Narasimha Ayyangar, chief engineer for irrigation, in general charge.

THE HARE AND THE TORTOISE

IN Galileo's time, scientists were looked upon as heretics because they upset the established order of things and asked men to discard cherished ideas and theories. Scientists are not in danger at present of losing their heads; but there is little doubt that they are disturbing the balance because of the rapid succession of their achievements. Industry, which has fostered scientific research, is discovering that it cannot always keep pace with laboratory developments.

The trouble lies in the fact that industry must make a profit to survive. But the men who work in laboratories do not have their eyes on profits, and they continue to find new and better methods of doing things and to provide cheaper and more effective products to serve given purposes. So far as the general public is concerned, this is well and good, but for a manufacturer it often means embarrassment. If he scraps the old for the new he is frequently faced with cutting his profit to the point where returns diminish quickly. Perhaps he has expended large sums in plant and equipment which will be rendered obsolete by the changeover. Research, in such cases, becomes a foster child that has developed an appetite that threatens to eat its benefactor out of house and home.

Two new books, *Tools of Tomorrow* and *The Frustration of Science*, enlarge upon aspects of these statements. In the former the quandary of the automobile manufacturer is discussed. It reveals that a $200 automobile is mechanically possible. True, it would have none of the luxuries of superspeed, shininess, fine upholstery, and innumerable gadgets that even our small cars now have; but it could be run at far less expense than they can. So far, the American standard of living has demanded the finer cars; but a large part of the world cannot afford them, and it is brought out that if American manufacturers do not make the cheaper kind some other nation will do so.

The second book goes more directly to the point. It shows that, during the dark days of the depression, industry hardly dared risk the investment of much of its capital for the purpose of bringing out improved products that were the fruit of research. As a result, a considerable backlog of scientific achievements has been built up; and, likely, it will be years before industry can absorb them in the economic scheme that largely controls it.

It is claimed that a new process for making iron at low temperatures has been devised. It would produce lower-priced iron; but in the meantime it would also cause the scrapping of much equipment now in use, thereby bringing about a terrific loss. Accordingly, the introduction of the new process must come gradually. It is similarly asserted that a new gas-discharge electric-light bulb requiring less power to operate than the present type is a commercial possibility. Thus, the problems of management are sometimes such as to put, temporarily at least, a checkrein upon advancement.

OUR COVER PICTURE

BOULDER Dam is shown as it appeared on March 13. Except for ornamental structures, the huge concrete plug has reached its full height. The 8-foot central slot is still open to permit cooling of the upper section by circulating water.

Just back of the dam, on either side of the canyon, are the twin 385-foot intake towers. Farther back from the river are the enormous concrete-lined spillways which will serve as outlets in case floods overtax the capacity of the intake-tower discharge system. Further examination of the canyon rims reveals all or part of four of the tracks for the cableway towers.

Just downstream from the dam, in the lower right-hand corner, the U-shaped power house is under construction. The line which winds down from the top of the dam on the far side is the scenic highway which will cross the structure.

CEMENT FOR ALL PURPOSES

TO THE layman, cement is cement, but engineers and construction men know that there are actually many kinds of this important material. In fact, there is a marked trend in this country away from a standard cement for construction purposes, according to P. H. Bates of the National Bureau of Standards.

In a recent paper, Mr. Bates pointed out that consumers are insisting on more and more varieties to meet special needs. In addition to standard portland cement, those in greatest demand are: low-heat-of-hardening cement such as is being used at Boulder Dam; cements that are resistant to sea water and to other waters containing chemically active salts: and high-early-strength cements such as are employed for road and street paving. Sometimes a special cement will effect savings in construction costs by making it possible to use lighter sections than would otherwise be the case or by speeding up the progress of the work. Wherever large quantities of concrete are called for, it is now usually the practice to conduct investigations so as to determine the kind of cement that will prove most effective and most economical for the particular job.

A CORRECTION

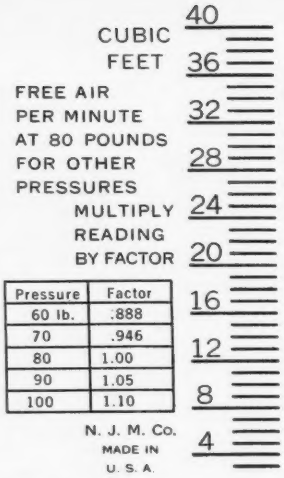
The name of the author of *Building a Parkway with Relief Labor*, which appeared on page 4681 of our March issue, was erroneously printed as Francis X. Conrad instead of Frederick X. Conrad. Mr. Conrad is city engineer of Port Jervis, N.Y.

A SHIPLIKE SERVICE STATION

AS BEFITS its location on the historic old Fisherman's Wharf in San Francisco Harbor, the automobile service station shown here is patterned after the deckhouse of a ship. The paved area it occupies, which is partly inclosed by a ship's rail, represents the deck. A circular, glass-fronted replica of a pilot house serves as the office and display room. Directly above is a hurricane bridge, fitted with ship's ports. Forward of the bridge is a signal mast, topped by a riding light. Port and starboard running lights, life preservers, and other ship's properties add to the marine atmosphere.

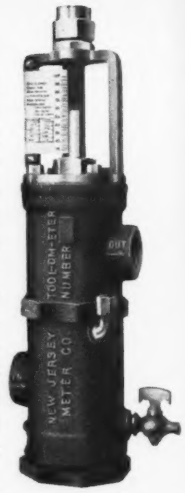
The wharf is in the center of the bay region's fishing industry. San Franciscans have visited it for generations to secure fresh fish, crabs, lobsters, and shrimps. From it the sturdy Italian fishing boats put out through the Golden Gate, and to it they return from the fishing banks to unload their catches. Landward, it is surrounded with markets, cafés, and sea-food bars; and on the sidewalks stand the great pots in which crabs and lobsters are cooked.

The service station was constructed by Standard Stations, Inc., and is one of more than 1,000 maintained on the Pacific Coast by that organization. It provides complete one-stop service for motorists, including tires, batteries, and accessories. Its equipment is as modern as the architecture of the structure. Compressed air, an indispensable adjunct, is supplied by a 1½-hp., Type 30, air-cooled compressor driven by a ball-bearing motor and fitted with an automatic pressure regulator, air filter, and intake muffler. The air is used for general purposes and for operating a grease-gun rack. As the old wharf is a bustling place both day and night, the station is open for business the 24 hours round.



Pressure	Factor
60 lb.	.888
70	.946
80	1.00
90	1.05
100	1.10

AIR METER FOR LOW-PRESSURE PNEUMATIC EQUIPMENT



USERS of pneumatic equipment will find it to their advantage to keep an eye on air consumption. It is what might be called the pulse and, if abnormal, indicates that something is wrong and should have attention. It may be only a matter of regulating the supply, or it may be a leak in the line. On the other hand, it may be that the tool employed for a certain service is not the one best suited for it or that it is in need of repairs. Again, the equipment may be obsolete—an "air eater" that should be discarded. Anyone of these will adversely affect the operating cost and will do so in proportion to the amount of air wasted.

To help them keep a check on the air consumed and to trace the source of the trouble, if any, there are available meters or gauges of different kinds. One of the latest of these is the Expanded Scale Tool-om-eter so called to distinguish it from the standard Tool-om-eter also manufactured by the New Jersey Meter Company. It has been designed to meet the need for a measuring instrument suitable for the smaller pneumatic tools and machines that take from 4 to 40 cfm. of air at from 80 to 100 pounds pressure.

The newest form of Tool-om-eter consists essentially of a cylinder and of one moving element which floats on air and which is made up of three parts: a piston in the cylinder, a smaller piston in an oil dashpot below, and a connecting piston rod. The cylinder has several vertical rows of orifices which are on a helical path—each opening being at a uniform height from the preceding one in the series. The number of orifices open to the air flow is determined by the position of the piston in the cylinder, and this position is made visible by the piston rod which extends up and into a sight glass alongside which a scale plate is mounted.

The instrument is of rugged construction, and all its contact parts are of bronze. It can be quickly coupled by hose to any tool and will give a reading in a few seconds, no mathematical formulas or calculations being required. There is a full division on the scale plate for each cubic foot of air—that is, the calibration is such as to indicate quarter feet with certainty or to estimate the flow within one-tenth of a foot with an error of 0.1 cubic foot plus or minus. Except when used for control purposes—as in the case of air lifts, when it is interposed permanently in the line, a meter can be shifted from place to place and thus serve to keep tabs on the air consumption of a number of machines or tools.

CURING CONCRETE BY MACHINE

CONCRETE paving is cured in many different ways, but generally by hand methods. To regulate and to speed up the work, the Tarrant Manufacturing Company of Saratoga Springs, N. Y., has designed a machine that can be conveniently pulled along by one man and that applies a film of asphalt emulsion the full width of a slab, including its vertical edges.

The emulsion is sprayed with compressed air, which is automatically regulated. The long spray bar carried at the back is provided with ten nozzles of which eight direct the fluid straight down on to the pavement while the two others—one at either end—serve to coat the sides. The bar is adjustable without the aid of tools and, together with the air lines, can be dismantled and assembled by hand.

According to the builder, the emulsion is distributed uniformly and without misting, thus preventing it from being blown on to nearby equipment or adjoining slabs of concrete. One machine will effectually seal a day's pouring of one paver in from one to two hours. More than 100 miles of concrete slabs were cured by machines of this type in New York State last year; and the contractors using the improved method report that it enables them to effect considerable savings in cost.

Industrial Notes

Two tractors and four generator sets, all equipped with diesel engines, have been shipped by the Caterpillar Tractor Company to Midway and Wake islands—the tiny coral dots in the Pacific Ocean that will serve as bases for the new transpacific air lines being established by Pan American Airways. The tractors will do pioneer grading work, and the generator sets will furnish lights for the landing fields. A feature of the operation of the generator sets will be their use as fuel of spent lubricating oil that will be drained from the airplanes and centrifuged.

A new type of compressed-air purifier, which is designed to take out oil and organic vapors in addition to water vapor and dust, is being marketed by the E. D. Bullard Company, San Francisco, Calif. The air is led through three layers of filtering compounds. The first removes oil, the second water vapor, and the third organic vapors and dust. This purifier is made in three sizes, ranging in capacity from 10 to 125 cfm. The filtering elements can be replaced when necessary, which is once a year under normal service conditions. Literature describing the purifier and its adaptation to various industrial needs is obtainable from the manufacturer.

State laws against stream pollution are forcing offenders to make other disposition of their waste and, in some cases, with benefit to themselves. Pickling solutions from steel mills have been among the most serious sources of pollution, but, thanks to a process of recent invention, can be made to yield sulphuric acid which is a basic chemical of industry and in wide demand. In addition, there is obtained a residue cinder of iron oxide that also has many uses. The Titanium Pigment Company, St. Louis, Mo., is successfully reclaiming these products from ferrous sulphate in a plant built for it by the Chemical Construction Company.

Tamms Silica Company has lately announced an improvement in its foundry-pattern compound known to the trade as Tamastone. The new material is called Super Tamastone, and is said to be six times stronger. It can be used to mount metal gates and small wood or metal patterns and thus convert a loose-molding into a match-plate job. For a match plate up to 12x18 inches in size, about 10 pounds of the compound are required; and from the time the molder begins to ram up until the plate is cleaned and ready to run is less than an hour. Such a plate, based on the 500-pound price for Super Tamastone, will range in cost from $2 to $2.50.

Three-day air-mail service is being established between Germany and Brazil. This is made possible by new planes that can cover the regular route without stopping to refuel midway, as is now the case. This means a reduction in time of 48 hours per trip.

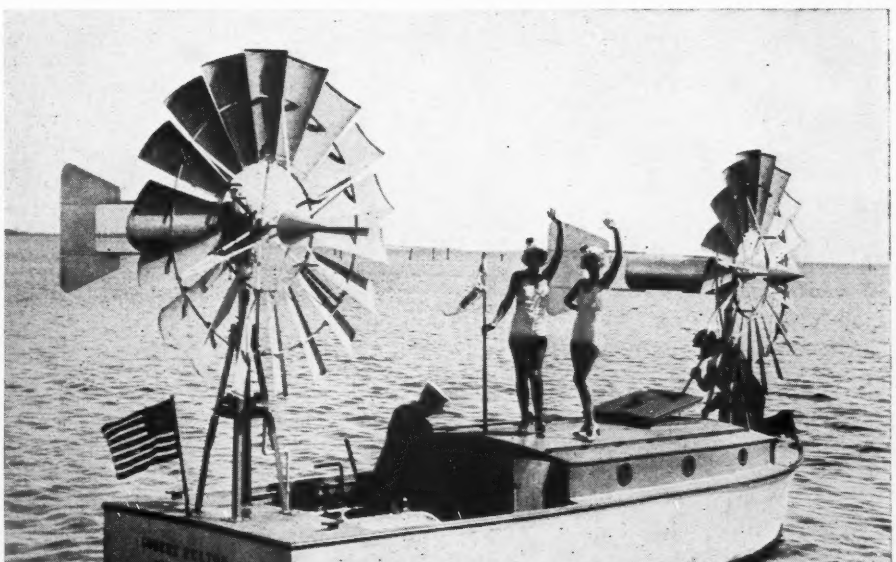
Careycel is a new heat-insulating material designed for pipes, boilers, tanks, ovens, etc., and for temperatures not exceeding 300°F. It is available in boards, panels, blocks, or split cylindrical sections. The latter are supplied with either a canvas or an asbestos paper jacket and with brass-lacquered steel bands.

Sticking coal, either lump or pulverized, can be a source of considerable annoyance in plants where it is burned in large quantities. One operator has overcome the difficulty by the use of an air-operated hammer. This he has set up in the center of the bin where it functions automatically at predetermined intervals, depending upon the amount of fuel required.

What kind of dust do you stir up in your factory? A rock-crushing plant, for example, has found that its by-product dust is of commercial value and, as an asphalt filler, is actually worth more than the rock itself. A coal-cleaning establishment is having the same experience, and is selling the dust from coal that has a market value of $1.75 a ton for $6 a ton to foundries where it is used as a mold facing. It may, therefore, pay you to collect your dust for other than sanitary reasons.

In a new 48-page bulletin, Ingersoll-Rand Company, 11 Broadway, New York, N. Y., fully describes and illustrates its "Calyx" core drills and the work which they can do. They come in various types and sizes to drill small holes up to 11½ inches in diameter and 2,500 feet deep and large holes up to 72 inches in diameter and 50 feet deep for the extraction of cores and for the examination of underground formations in place. A copy of *Calyx Core Drills*, Form 9501, may be obtained from the manufacturer.

A new metal cleaner has been put on the market under the name of Magnusol. It is said to remove oil and grease from small metal parts and from heavy automotive and construction equipment with equal facility, and to be noninjurious either to worker or machinery. The product can be obtained in base or solvent form, for mixing with kerosene or ready for use, and is applied by brushing, spraying, or dipping. Penetration of the solution is effected in a few minutes, after which a stream or bath of water completes the process, leaving the surfaces clean.



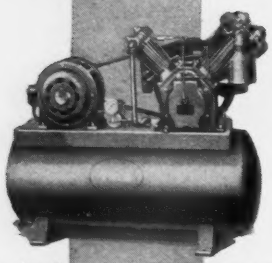
International News Photos, Inc.

IT'S AIR THAT MAKES IT GO

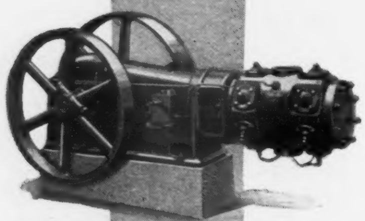
This unique pleasure craft is attracting attention in the waters off Miami, Fla. It is the invention of Palmer H. Crary, a descendant of Robert Fulton of steamboat fame. Propulsive power is developed by means of the windmills on the deck, each of which operates a pump that forces air into a large pressure tank. It is said to be sufficient to drive the craft along at high speed.

AIR-LIFT PUMPING

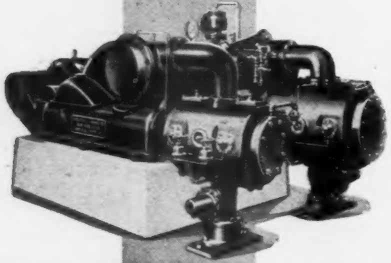
for Low Maintenance Cost and Long Life . . . . .



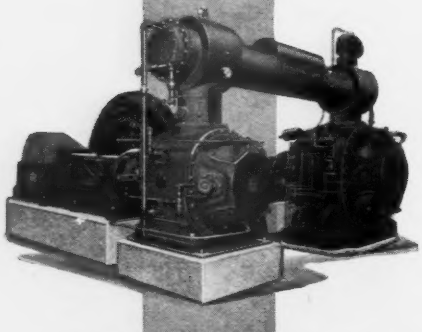
Type 30 Two-Stage Air Compressor



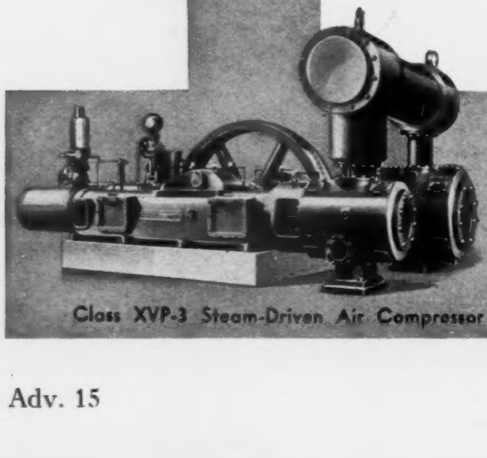
Class ES Single-Stage Belt-Driven Air Compressor



Type XCB-2 Belt Driven Air Compressor



Class PRE-2 Direct-Connected, Electric-Motor-Driven Air Compressor



Class XVP-3 Steam-Driven Air Compressor

THE Air-Lift System of pumping as pioneered and perfected by Ingersoll-Rand has many practical applications. Originally used only for the handling of water from drilled wells it is now successfully used for pumping oil wells, brine wells, etc.; for dredging, dewatering mines, agitating solutions; for lifting pulp, tailing and other liquids of a gritty or corrosive nature.

Since there are no moving parts in the well, and since all the apparatus above and below the surface is extremely simple, maintenance costs are small and long years of trouble-free operation are assured.

The dependability and efficient operation of the Air-Lift is almost wholly dependent on the compressor. Ingersoll-Rand offers for this service over a 1000 sizes and types of compressors designed to meet the particular demands of any Air-Lift pumping job.

Besides the compressor, all accessory equipment such as receivers, pipe lines, head pieces, well caps, supporting clamps, and tapered discharge pipes are furnished to suit the conditions of any air-lift system.

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